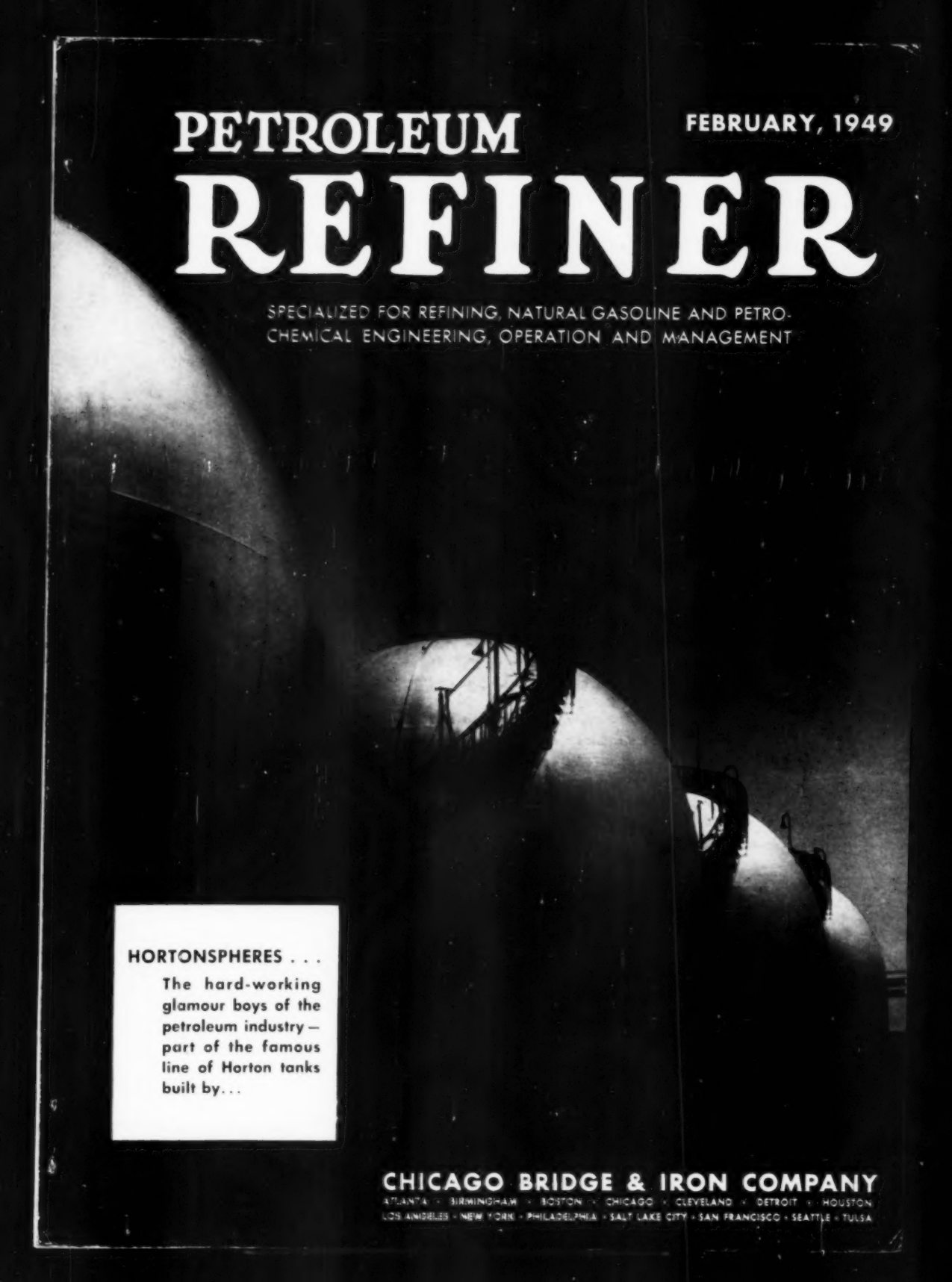
FEBRUARY, 1949

PETROLEUM REFINER

SPECIALIZED FOR REFINING, NATURAL GASOLINE AND PETROCHEMICAL ENGINEERING, OPERATION AND MANAGEMENT



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The hard-working glamour boys of the petroleum industry—part of the famous line of Horton tanks built by...

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In Refinery Service

Those little traps with the big thirst—Yarway Impulse Steam Traps—are doing a giant's job in hundreds of refineries throughout the country.

Yarways are ideally suited not only for refinery work, but for all industrial trapping service. They literally *drink* the condensate—discharging *continuously* on heavy loads, *intermittently* on light loads. Hence they provide maximum heat in the shortest possible time to keep equipment at top efficiency.

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See your nearest Supply House, or write for Bulletin T-1739.

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for the drilling-producing-pipe line industry

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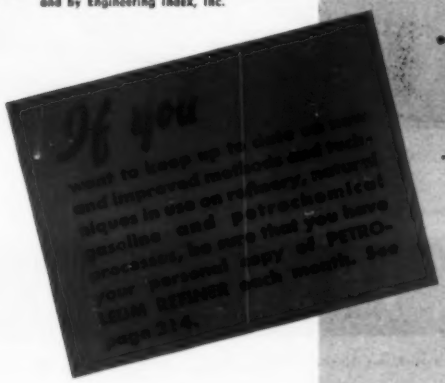
If you
want to keep up to date on new and improved methods and techniques in use on refinery, natural gasoline and petrochemical processes, be sure that you have your personal copy of PETROLEUM REFINER each month. See page 214.

PETROLEUM REFINER

Specialized for Refining, Natural Gasoline and Petrochemical Engineering, Operation and Management

R. L. DUDLEY, President, Publisher . A. L. BURNS, General Manager

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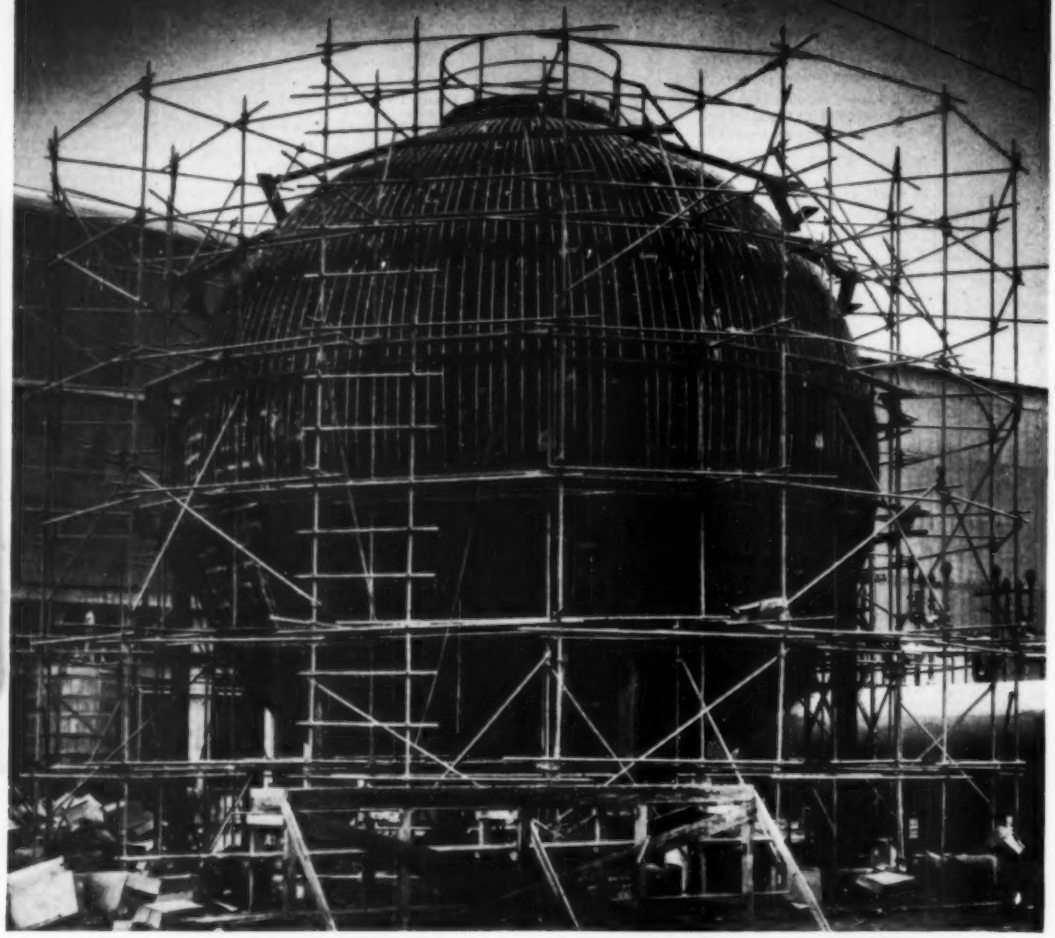
Now... a permanent insulation for industrial use



Insulating this spherical tank, used for storing liquid ammonia at 20°F., presented many unusual problems. These were met successfully by PC Foamglas—the only material of its kind—composed of millions of tiny glass cells filled with sealed-in air, which is waterproof, fireproof and vaporproof, and which keeps its original insulating efficiency *permanently*.

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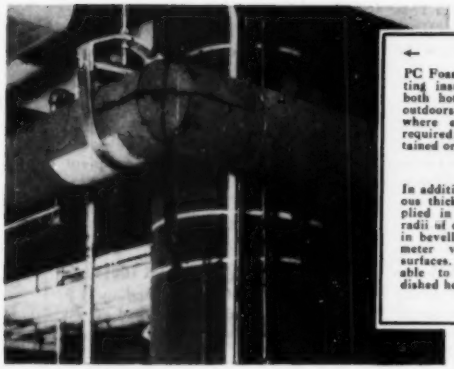
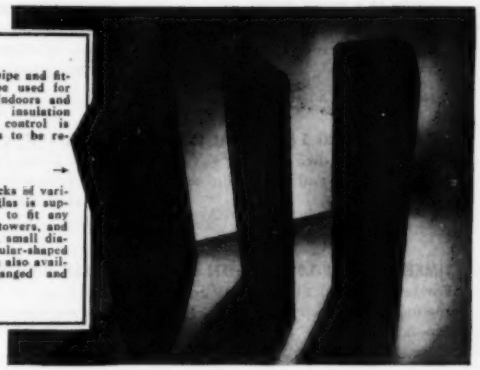


PC Foamglas is the only pipe and fitting insulation that can be used for both hot and cold lines—indoors and outdoors. It's the ideal insulation where exact temperature control is required; wherever heat is to be retained or excluded.

In addition to standard blocks of various thicknesses, PC Foamglas is supplied in preformed shapes to fit any radii of circular tanks and towers, and in bevelled lags for domes, small diameter vessels and irregular-shaped surfaces. Shaped material is also available to fit spherical, flanged and dished heads.



PC FOAMGLAS . . . for hot and cold applications . . . for indoor and outdoor use

IT'S WEATHERPROOF, FIREPROOF, WATERPROOF, VAPORPROOF

● On process equipment and piping, PC Foamglas withstands humidity; helps maintain desired temperature levels; aids in minimizing condensation. And, since PC Foamglas is a true glass . . . not a fiber, wool, board or batt . . . it is waterproof, fireproof and verminproof—proof against the elements that cause other materials to deteriorate. It's a fact that when PC Foamglas is installed according to our specifications for recommended applications, it retains its original insulating efficiency *permanently*.

PC Foamglas requires no protective covering, either. There aren't the costly repairs, replacements and maintenance involved in other insulating materials.

What's equally important, PC Foamglas is light weight; easy to handle. It can readily be cut with a knife in straight lines or odd shapes. And because it's friable, when subjected to point loading, it yields to such surface irregularities as rivet heads and welds. Thus it can be pressed close to the area to be insulated without breaking or cracking; it can be shaped to curved surfaces of all radii.

Remember, first cost is last cost when you insulate tanks, towers, heat exchangers and other processing equipment with permanent PC Foamglas. But why not get full and up-to-date information? Fill in and return the coupon for our free booklet. There's no obligation.

This is FOAMGLAS

The entire strong, rigid block is composed of millions of sealed glass bubbles. They form a continuous structure, so no air, water, vapor or fumes can get into or through the Foamglas block. In those closed glass cells, which contain inert air, lies the secret of the material's permanent insulating efficiency.

FOR ADDITIONAL INFORMATION SEE OUR INSERTS IN SWEET'S CATALOGS

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When you insulate with Foamglas ...you insulate for good!

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TIMKEN 2¼% CR-1.0% MO STEEL TUBES For service up to 1150°F. Has greater resistance to creep than 2% Cr. ½% Mo. Steel.	**TIMKEN SICROMO 2 STEEL TUBES** For service up to 1200°F., where better scale resistance is required than can be obtained with 2% Cr. ½% Mo. Steel.	**TIMKEN 2% CR ½% MO STEEL TUBES** For service up to 1150°F. Intermediate corrosion resistance plus good creep strength, fair oxidation resistance.
TIMKEN DM STEEL TUBES For service up to 1150°F. This steel offers outstanding creep strength.	**TIMKEN CARBON-MO STEEL TUBES** For temperature up to 1000°F. Improved creep strength makes it safer than carbon steel.	**TIMKEN CARBON STEEL TUBES** Generally for service not exceeding 900°F., where corrosion and oxidation resistance are not important.

12 steels with a single aim— a better LIFE/COST ratio for your tubes!

THE twelve steels listed here were developed to meet many different high temperature tube requirements. But they all have one thing in common: each will give you the best possible life/cost ratio for a particular set of operating conditions.

Which one will best solve *your* problem of heat, pressure, corrosion, or oxidation? Metallurgists of The Timken Roller Bearing Company can tell you. You can depend on their recommendations because 19 years of experience and research have made them the recognized authorities on high temperature tubing applications.

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The Timken Technical Staff will be glad to study your high temperature tube problems. Call upon them at any time without obligation. For further information on Timken high temperature tubing, write for your copy of "Facilities and Products", The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

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SMALL STEAM LEAKS *add up!*

Showing cost of various sized steam leaks at 100 pound pressure. (Assuming steam costs 50 cents per 1000 lbs.)

Size of Orifice	Lb. Steam Wasted Per Month	Total Cost Per Month	Total Cost Per Year
1/2"	835,000	$417.50	$5,010.00
3/8"	470,000	235.00	2,820.00
1/4"	210,000	105.00	1,260.00
1/8"	52,500	26.25	315.00
1/16"	13,200	6.60	79.20
1/32"	3,400	1.70	20.40

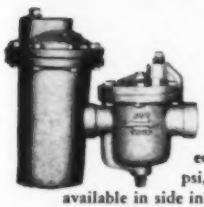
(For steam at 50 pounds pressure, the waste is about 75% of the above figures; at 20 pounds, it is about 50%; and at 5 pounds, the loss is about 25%.)

TYPICAL FUEL SAVINGS SECURED WITH ARMSTRONG TRAPS

20% FUEL SAVINGS after trapping all heating coils individually. — Norton Greenhouses, St. Paul, Minn.

33-1/3% REDUCTION IN ANNUAL COAL BILL after installing Armstrong traps on cooking vats. — Ralph L. Smith Lumber Co., North Kansas City, Mo.

3,728 GALLONS OF FUEL OIL SAVED in one year after replacing old traps with Armstrongs on kettles, low pressure heating system and cream beaters. — Mary Lincoln Candies, Buffalo, N. Y.



STEAM SAVERS:

For trapping heating systems and process equipment from 1 to 250 psi, Armstrong Traps are available in side inlet—side outlet or bottom inlet—top outlet body styles. These compact, dependable traps provide more actual hot condensate capacity per dollar of trap investment than any other traps on the market. For selection data, capacities and prices SEND FOR the 36-page ARMSTRONG STEAM TRAP BOOK.

CHECK YOUR STEAM TRAPS *now!*

The chart above shows that a "little" steam leak can cost a lot—and a hundred or a thousand little leaks cost a lot more! No plant can afford the luxury of leaky steam traps. It costs far more to keep them than it does to replace them with modern Armstrong Inverted Bucket Steam Traps. Armstrong Traps won't leak steam because:

1. The valve and seat are ground and lapped to a precision, steam-tight fit.
2. The valve is water-sealed at all times.
3. Both the valve and seat are made of chrome steel, heat treated for long life and corrosion and erosion resistance.

With today's high fuel and operating costs Armstrong traps are priced lower in proportion to the savings they can effect than at any time in their history. Let your nearby Armstrong Representative help you select the traps you need or write direct to the factory.

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different analyses

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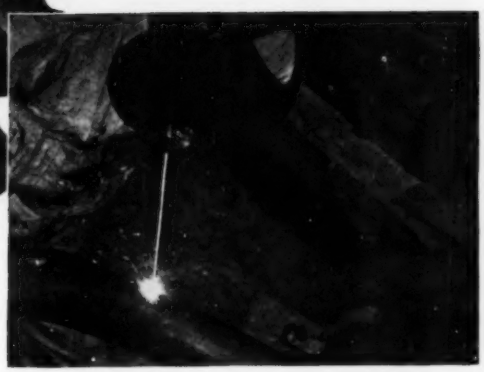
. . . for pipe welding equipment and "know how"



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Both the oxyacetylene flame and electric arc provide valuable aid to the industry in many ways — in welding transmission pipe lines and refinery piping; in the fabrication, erection and alteration of structural units; in rebuilding and repairing worn and broken equipment of every type.

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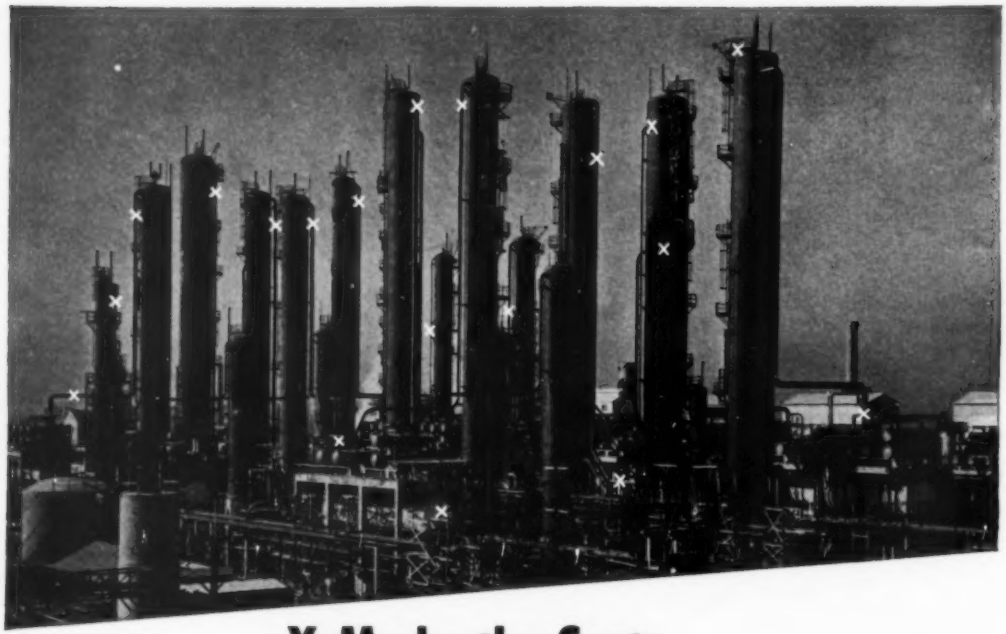

X Marks the Spots For Speedomax Pneumatic Control

Can a refinery operate at maximum yield with just one general type of temperature controller for most of its needs? Engineers in at least one plant used to think not, but a recent experience now makes them suspect that the new, complete, L&N Pneumatic Controller can replace many of the controller types formerly used.

Tower Was In Trouble

In this plant, a tower-top instrument recently had to be replaced because it started failing to hold the 215F top temperature within limits. The only standby controller was a standard Speedomax of 0-1000F range. This range is of course not right for tower top, but the tower was in trouble; some instrument had to be found at once. Speedomax was rushed into service without even time to change its range.

Speedomax Ended Control Difficulties

Results were far beyond expectations. For example—when the operator had to lower the control temperature by only two degrees, Speedomax handled the change immediately, without overshooting, even though the control point was way down scale and the range was wrong. In fact, Speedomax gave better control than other instruments having the special range, etc., for tower top control.

Speedomax Control Is Complete

Reasons for such success are the sensitivity of Speedomax plus the complete L&N Pneumatic-Control System. The Control's Rate Action is highly stable—thoroughly resistant to upsetting factors. The control point moves only when the operator moves it by hand. Automatic droop correction and bumpless transfer from manual to automatic operation are among other features. For information write Leeds & Northrup Company, 4923 Stenton Ave., Philadelphia 44, Pa.

Here's A New Catalog You Can't Afford To Miss

Suggested uses for this controller, and a description of its operation are presented in this new 24-page catalog.

In addition, the catalog lists our Micromax and Speedomax Pneumatic Controllers for temperature, per cent SO_2, electrolytic conductivity and pH. Ask for catalog ND4B.

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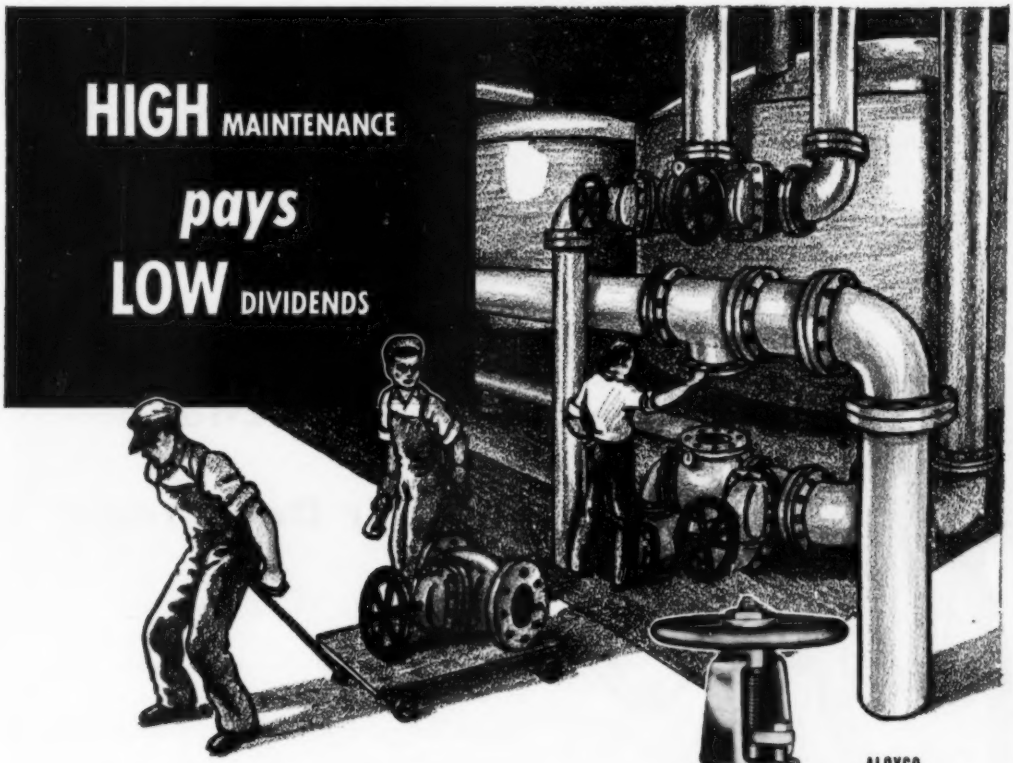

ALOYCO GATE VALVE NO. 111

save money with ALOYCO VALVES

● Few manufacturers can afford the luxury of frequent valve replacement. With labor and materials at present day peaks and when down-time is considered the cost of replacing a valve in a corrosive fluid pipe line is excessive.

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NEW BULLETINS: Write the nearest A. O. Smith office listed above for these new Bulletins: V-44—Field Assembly of Pressure Vessels; V-46—SMITHway Vessels, Alloy, Alloy-Lined, Clad, and Glass-Lined.

BY WATER AND RAIL. A. O. Smith ships pressure vessels for the petroleum, paper, and process industries. The SMITH-lined Fractionating Tower above, one of the largest shop-fabricated vessels ever built (16 ft. diameter by 116 ft. long, weighing over 320,000 lbs.), is going by barge to an oil refinery in the Chicago area.

SOME 60 SMITHway PRESSURE VESSELS for both low and high temperature service have been ordered during the last four years by one company to equip two new plants. This SMITHway Tower, three railroad cars long, 116 ft. by 7 ft., weighing 137,000 lbs., is one of the types of vessels furnished.

THIS MAN KNOWS HIS CURVES: For 23 years, Frank Hilke has been shaping, to exact diameters, the shell courses of SMITHway Pressure Vessels. He uses a variety of rolls which can produce any diameter needed for pressure vessels.

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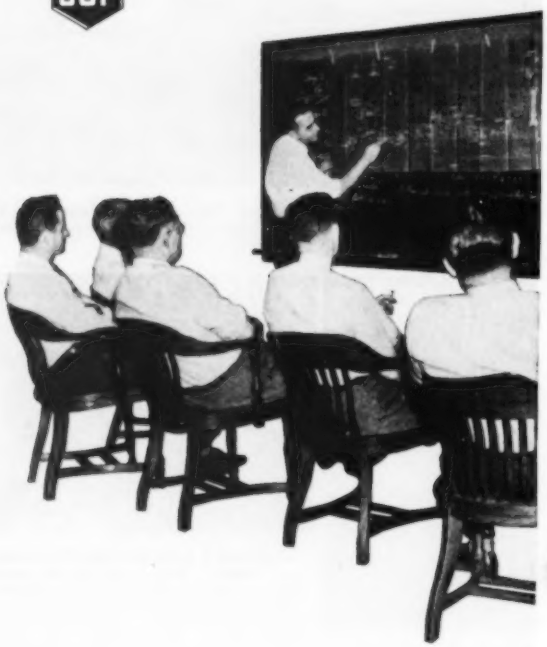
Q:
What single factor has done the most to bring economical, profitable operation within the reach of all refiners?

UOP



Converted War Refinery Gives Sunray 20,000 b/d

By F. L. Martin
Executive Vice-President
Sunray Oil Corporation

THE Sunray refinery near Duncan, Okla., is currently processing approximately 20,000 barrels of Oklahoma crude every day to produce a wide range of readily marketable products – not 100-octane gasoline for which the plant was originally designed.

F. L. Martin

Built and operated during the war by Associated Refineries, this plant had been producing about 250,000 barrels of aviation gasoline a month. When it was shut down at the close of the war, doubt existed generally that it could be operated profitably under peacetime conditions.

Purchased in 1947

After consultation with the refinery's designers, Universal Oil Products Co., we decided to negotiate its purchase which was completed in October 1947. Conversion to commercial operation, making the greatest possible use of existing facilities, was begun at once under Universal's direction.

This is what we had purchased: a two-stage fluid catalytic cracking plant with a charging capacity of 12,000 barrels of fresh feed per day; a gas concentration system; a hydrogen fluoride alkylation unit which produced 2,500 barrels per day of alkylate; an isomerization plant capable of producing 300 barrels per day of isobutane; and a modern boiler plant.

Auxiliary equipment included three large forced-draft cooling towers necessitated by the heavy water requirements of the alkylation plant. Tankage included rundown, charging stock and product storage tanks. There were, as well, buildings and shops and a large loading dock.

An adequate supply of crude was at hand from the nearby Velma field and low cost electricity and natural gas were available.

Objections to Overcome

Our new refinery possessed no pipe lines to afford economical transportation for crude coming in and product going out, inasmuch as it had been designed to operate exclusively on gas oil delivered by truck, and to produce aviation gasoline shipped by tank car.

The wartime equipment included no topping unit, an essential requirement for a refinery running crude oil. There was no desalting equipment, needed in treating Velma crude. A vacuum

(Advertisement)

unit was lacking for the recovery of heavy, waxy gas oil from topped crude. A vis-breaking operation would be required to make a salable fuel oil from the heavy residue. There was no provision for treating the products of crude distillation.

Changes Called For

Our original Sunray refinery with a capacity of 12,000 barrels per day is located at Allen, Okla., some 100 miles from Duncan by pipe line route. One of the first requirements was to connect the two refineries for product exchange and storage. At the same time, a short line was needed to bring crude from the Velma field to Duncan.

As operated in wartime, the light gases from the cat cracker were charged to the alkylation unit to produce aviation alkylate. Since that procedure was not applicable to our new operating schedule, it was desirable to install a polymerization unit and a propane separation unit to prepare this product for the LPG market.

We decided to operate the cat cracker as a single stage unit and extensive changes in both the reactor and regenerator sections were necessary. The large feed heater, no longer required, and the retreat fractionating column, were taken as basic elements for a new topping unit.

In order to increase the crude capacity of the converted plant it was decided to preflash the crude. A heat exchanger from the alkylation unit and the debutanizer tower from the gas concentration system were combined into a preflashing unit. Thus, about 15 percent of light straight run gasoline is flashed off when the charge to the crude unit is preheated to about 400°F. This improvised crude unit and the preflashing system give the plant its 20,000 b/d crude capacity.

A large settler from the alkylation unit was converted into a vacuum unit; a poly unit was built to handle the gases from the crude unit and the cat cracker; a propane unit was installed. In all these, existing equipment was utilized to a great extent.

Profitable Operation

Actual construction began in October 1947, and 90 days later the topping operations were processing 18,000 bbls. per day. On April first the vacuum vis-breaking operation started producing feed stock for the catalytic cracker, and on June first the catalytic cracker was on stream.

The cooperation received from Universal Oil Products Co. completely changed the plant from a wartime operation to a practical commercial refinery within nine months, including 98 miles of six-inch products pipe line construction.

This conversion at Duncan has resulted in a very successful and profitable operation for Sunray, and at the same time has balanced refinery run to crude oil production.

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Universal Service Protects Your Refinery

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...There's a CHAPMAN STEEL VALVE for every operating need

Whatever the temperature of fluids or gases, from —160° F. to more than 1000° F., Chapman has a steel valve that has been specifically designed to give trouble-free service.

Every valve in this extensive line is quality-controlled during every step in manufacture from the metals developed and produced in Chapman's own foundries to final shipment to you. And, though manufactured with production line speed and economy, each has the precision rating of custom-made valves—equalling or exceeding standard specifications.

It will pay you to check the Chapman line first before you order. For additional information on Chapman's unusually wide range of sizes and types, write today to:

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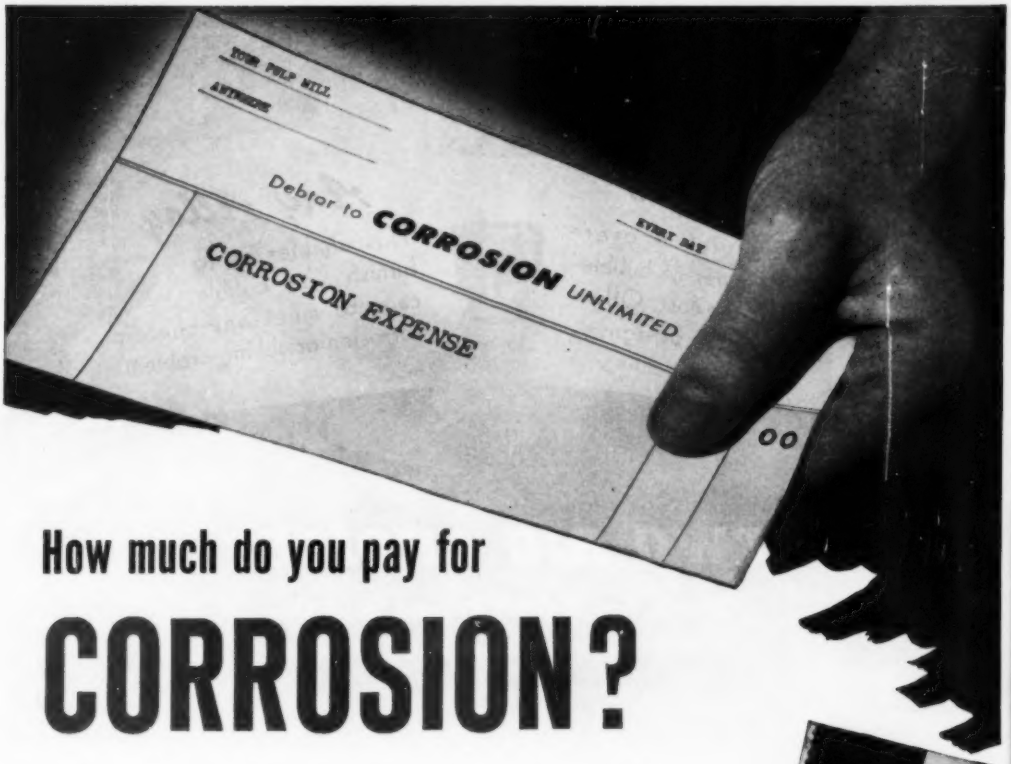

How much do you pay for CORROSION?

Corrosion is a definite item of cost in every refinery in the land. It runs up a bill that you and all other plants must pay.

The extravagant way to pay this bill is to use equipment that cannot successfully resist corrosion. High maintenance, excessive shutdown time and lowered quality of product create a hidden cost that continues as long as corrosion exists.

How to Reduce Your Corrosion Cost

There is a much less costly way to pay your corrosion bill—use *ESCO* stainless steel alloys and equipment. "Down time" is cut to a minimum, maintenance costs are extremely low, and uniformly high quality of product is maintained.

Corrosion resistance of *ESCO* alloys and operating efficiency of *ESCO* equipment have been thoroughly proved in plants in all parts of the country, under all kinds of working conditions. It will be equally effective for you.

Get New ESCO Catalog

Just off the press is a catalog of *ESCO* high alloy products. It pictures *ESCO* process equipment, illustrates various items with detail drawings, gives engineering data. New corrosion tables show resistance of *ESCO* alloys to a wide variety of acids, alkalines and salts.

A copy of this new catalog is yours for the asking. See your nearest *ESCO* representative, or fill in and mail the coupon below. Electric Steel Foundry, 2181 N. W. 25th Avenue, Portland 10, Oregon. Offices in Eugene, Oregon; Chicago; Honolulu; Houston; Los Angeles; New York City; San Francisco; Seattle and Spokane. In Canada, *ESCO* Limited, Vancouver, B. C.

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This enables us to furnish you bubble caps to meet any specific corrosion or coking problem.
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Which Are Making Pressed Steel Co. Bubble Caps the More Widely Chosen

THE fact that 60% of the oil industry's fractionating equipment are today using bubble caps by The Pressed Steel Co. points up the effective way in which we are helping our customers solve their problems.

First, we have dies for over 150 different styles of bubble caps, both round and rectangular. As a result we not only make prompt delivery, but we save many customers the cost of dies. Caps to meet special requirements will be promptly designed by our engineering department.

LESS COKING, FEWER CLEANOUTS

Another feature of our manufacturing service is that we fabricate bubble caps from the entire and complete list of alloys which are available today. Tell us your coking and corrosion problems, or any other conditions faced in your towers. We will then select the one alloy that best meets them. Because bubble caps by The Pressed Steel Co. are "alloy right", they obviously result in fewer cleanouts and more on-stream hours—as evidenced by plant records.

LET OUR TECHNICAL STAFF HELP YOU

In addition to the two broad advantages described above, The Pressed Steel Co. offers you a wealth of experienced engineering assistance and production know-how, gained through the almost quarter-century we have been supplying welded alloy equipment to the refining industry. Send blue prints or write as to your needs. The services of our technical staff are freely available. Also welded tubing, conveyor flights, etc., in sheet alloys to any specifications.

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Industrial Equipment of Heat and Corrosion Resistant WEIGHT-SAVING *Sheet Alloys*

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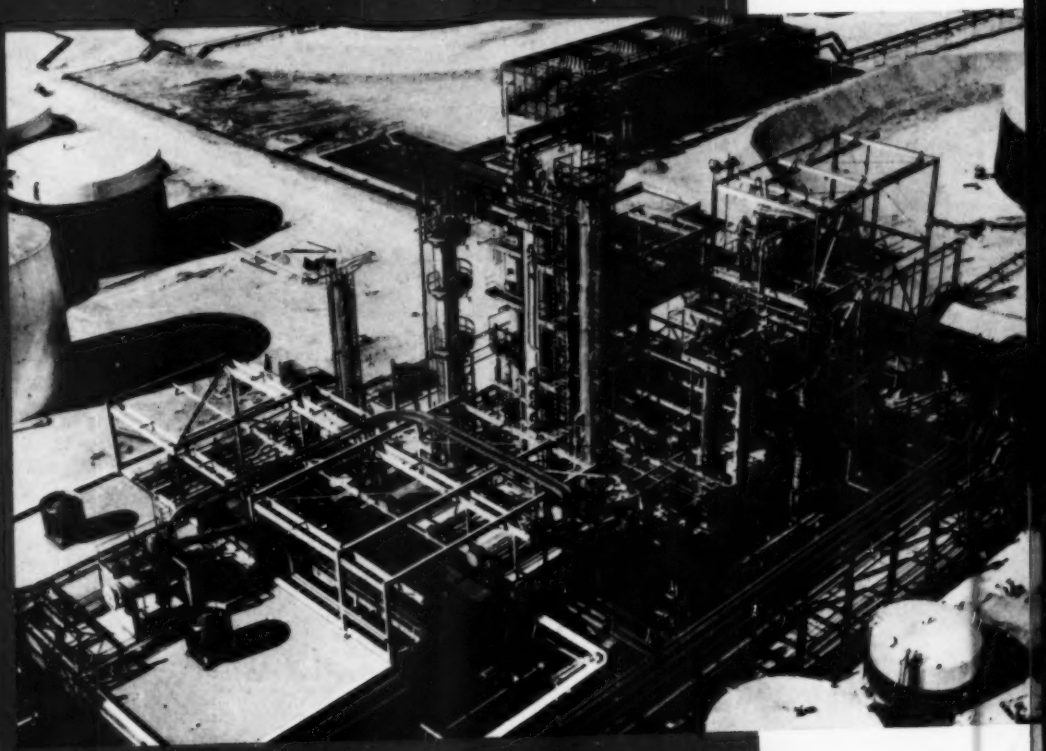


crude thruput doubled . . gasoline octane level raised

CONTINENTAL
OIL COMPANY'S
DENVER
REFINERY

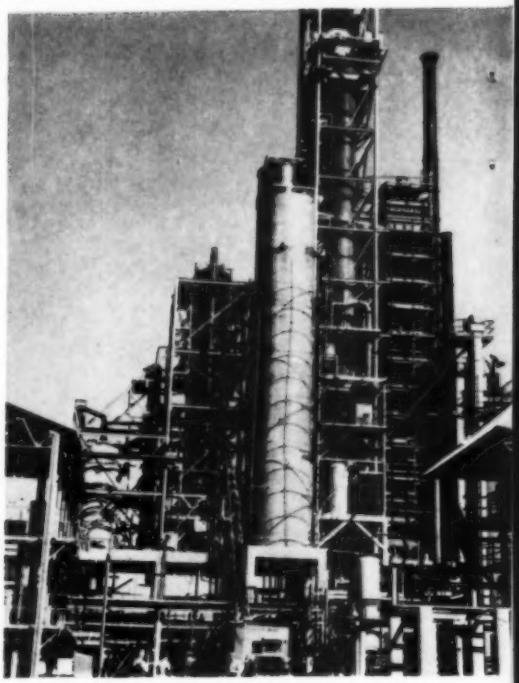
An interesting example of integrated expansion

The new Lummus-built catalytic cracking unit at Continental's Denver Refinery was recently completed. Despite unfavorable weather conditions it went on stream about the middle of November, and within two days it was operating at design capacity.

The catalytic cracking unit was part of an integrated expansion program that included the design and construction by Lummus of three other new units—gas recovery, catalytic polymerization, liquid propane gas fractionation—and the modernization by Lummus of a thermal cracking unit.

Continental's Denver Program is an interesting example of refinery expansion accomplished by integrating new units with modernized existing facilities. This program practically doubles the crude thruput at Denver and raises the octane level of the finished gasoline.

Lummus engineers are available for a thorough study of individual problems involving the modernization or expansion of existing facilities and the projection of new programs.



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Control Hungry Acids

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Type C "Y" Pattern

Men who need to tame biting acids and put them to useful work have long relied on lead. And they look to the leader in lead . . . National Lead Company . . . for dependable lead and lead-lined acid valves.

National Lead's "United" valves work efficiently at their routine jobs of controlling the flow of corrosive acids. But they also have the built-in stamina and sturdiness to withstand stresses and overloads well beyond their regular lines of duty.

Wedge Type Gate Pattern

The "United" valve you buy is representative not only of National Lead's resources in the lead products manufacturing field but also of resourcefulness in designing acid valves that make the most of lead's inherent corrosion-resistant properties.

Type D Check

Under the name "United," National Lead Company offers a complete line of hard lead and lead-lined flanged acid valves —"Y" and angle patterns, gate, check, foot and diaphragm.

Chem Rayon Angle Pattern

Diaphragm Pattern

Type R Reversible-Angle or "Y"

Look to the Leader for Lead

. . . in everything from lead pipe . . . valves . . . sheet . . . and lead-lined or lead-covered equipment . . . to complete acid recovery plants.

NATIONAL Lead Company

New York 6; Baltimore 3; Buffalo 3; Chicago 8; Cincinnati 3; Cleveland 13; Pittsburgh 12; St. Louis 1; Boston 6, (National Lead Company of Mass.); Los Angeles 23, (Morris P. Kirk & Son, Inc.); Philadelphia 25, (John T. Lewis & Bros. Co.); Atlanta (Georgia Lead Works, Div. of Cincinnati Branch); Toronto, Canada (Canada Metal Co. Ltd.).

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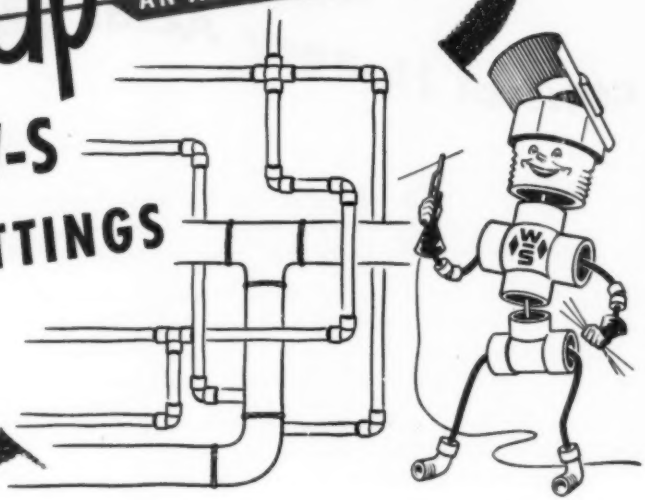
AN ALL-STEEL SYSTEM



MACHINED FROM SOLID DROP FORGINGS

There's sound planning in the little man's suggestion. He uses W-S Forged Steel Fittings below the practical butt-welding range . . . and has an *all-steel* system.

He does the whole job with *one* method by using W-S Socket Welding Fittings in nominal sizes from 2" down to ¼"... conveniently *welds all the way*. Then, where accessibility or other limiting factors require a screwed connection, he maintains the strength and uniformity of an *all-steel* service by using a W-S Forged Steel Screw End Fitting.

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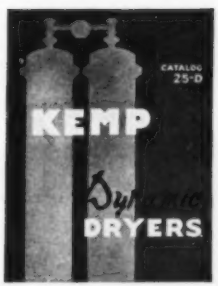
A note on the coupon below will bring you a skilled Kemp engineer or a 48-page booklet on Kemp Dryers.



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Please send a Kemp representative in to see me. ☐

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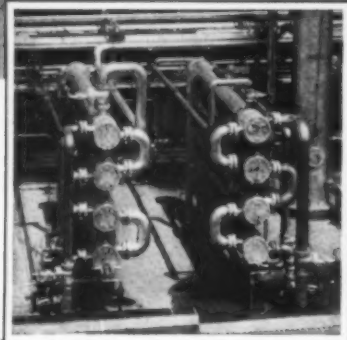
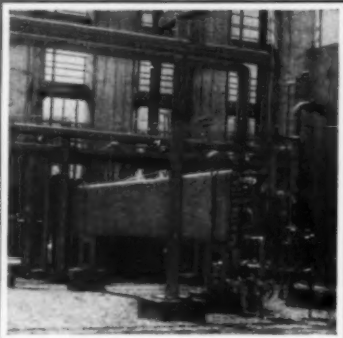
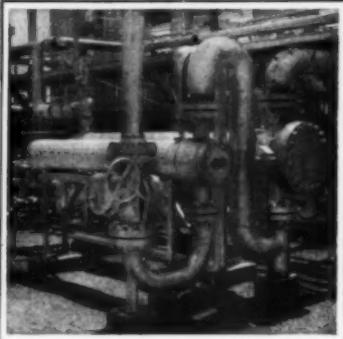


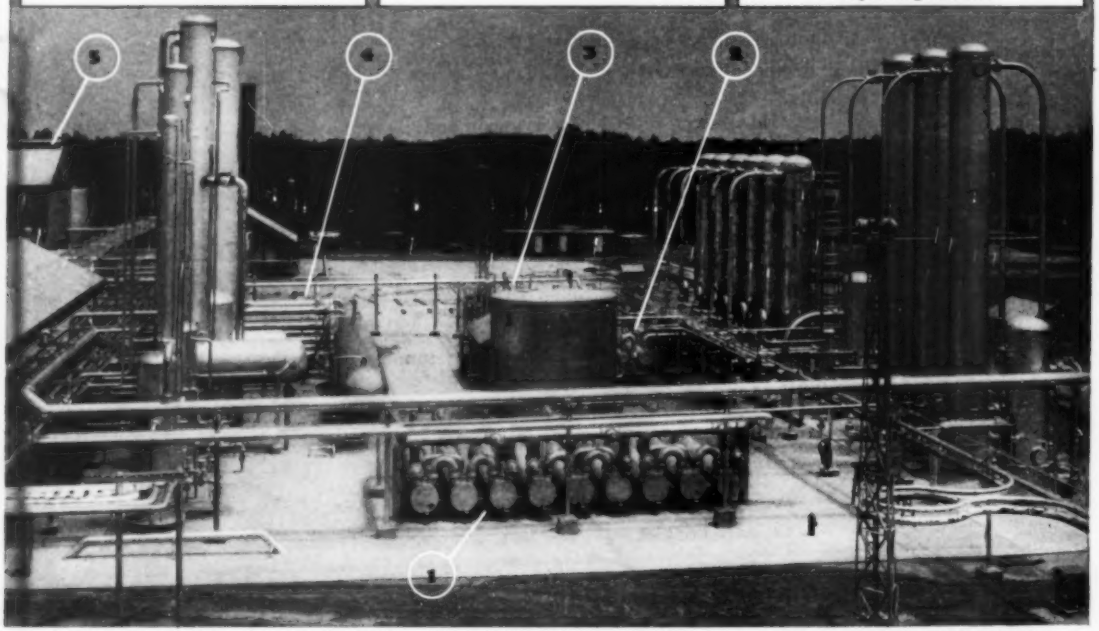
4. G-R Tubular Still Feed Exchangers and Preheaters



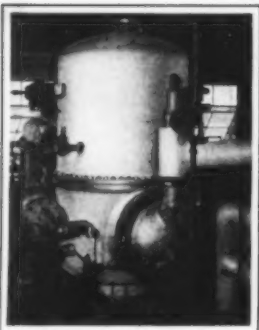
3. G-R Twin Bare Pipe Section Boiler Feedwater Exchangers



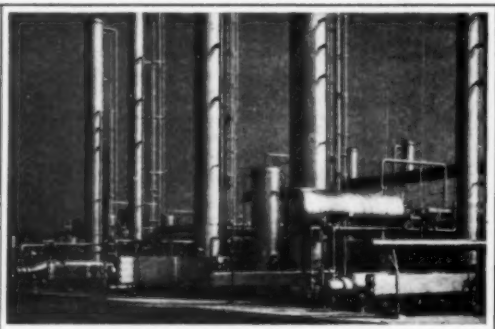
2. G-R Tubular High-Pressure Gas Heaters for regeneration of dehydrating material



1. General view of portion of the Feasel and Kinsey Plant of Chicago Corp., at Carthage, Texas, showing a row of nine G-R Tubular Units used as main exchangers in the foreground



5. G-R Bentube Evaporator for distilling the feedwater make-up for the high-pressure boiler plant



G-R Kettle Type Reboilers and G-R Twin G-Fin Section Fractionator Column Feed to Product Exchangers

Two of more than 60 G-R Atmospheric Bentube Sections for all cooling services, including extremely high-pressure gas cooling

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Heat Transfer Apparatus

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The Chicago Corporation has had lengthy experience with G-R Heat Exchangers . . . they have successively installed many G-R units of various types at their Wardner, Coastal and Gulf Plains Recycling Plants.

The excellent performance of these previous G-R installations has justified their continued use of G-R Heat Transfer Apparatus throughout the new Chicago plant at Carthage, Texas. Here, as shown in the illustrations, a total of more than 100 G-R units of the following types have been installed:

Atmospheric Bentube Sections
High-Pressure Gas Heaters
Tubular Exchangers
Kettle Type Reboilers
Twin G-Fin Sections
Twin Bare Pipe Sections
Bentube Evaporator

This installation indicates two significant points of importance to *every* user of heat transfer apparatus:

1. The many different types of G-R equipment . . . an exactly suitable design for every heat transfer requirement
2. The outstanding success of G-R installations . . . winning repeat orders and exclusive standardization on G-R equipment

Bulletins describing G-R apparatus for heat transfer services in which you are interested will be sent on request.

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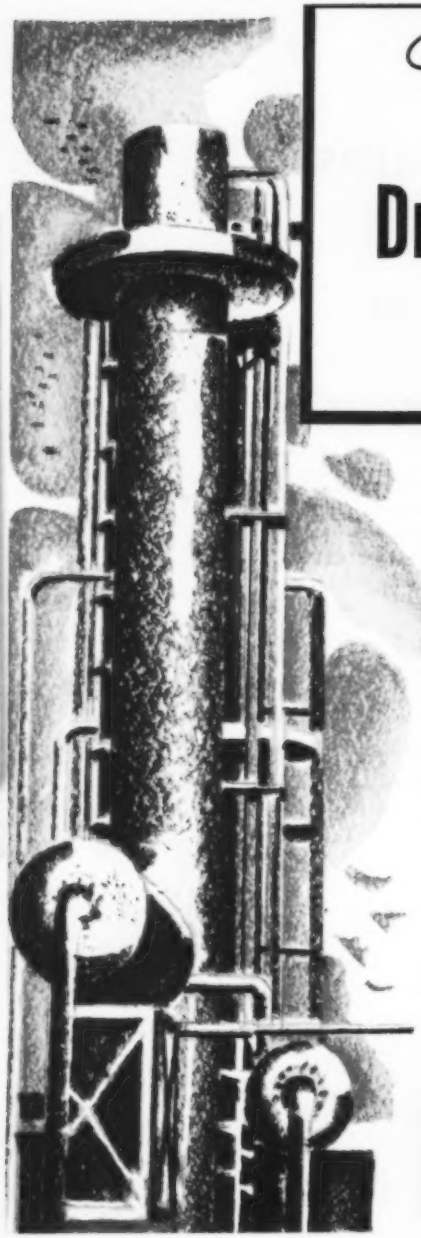
FOR GASOLINE SWEETENING



Available in 3 types

$2H_2O$ Crystal
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IMMEDIATELY AVAILABLE FROM STOCKS

Specify Harshaw Copper (Cupric) Chloride—an efficient gasoline sweetening agent for use with several standard recognized processes.

There is no better recommendation for Harshaw Copper (Cupric) Chloride than the long list of refineries which find this material necessary for their operations.

Your needs, too, will be satisfactorily met when you choose any of the three types of Harshaw Copper (Cupric) Chloride.

Typical analyses are:

Copper Chloride $2H_2O$ Crystal—35.4% Cu
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Copper Chloride Anhydrous—46.5% Cu

All are immediately available from conveniently located stocks. Contact the Harshaw branch office nearest to you for your requirements.

CATALYSTS ... Another Harshaw Product Serving The Petroleum Industry

THE HARSHAW CHEMICAL CO.
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stumped by tube selection at your plant?

You will probably find just the answer to your tube problems among

NATIONAL'S

25 different analyses!

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- 2 CR., ½ MOLY., 1-¼ SIL.
- 2-¼ CR., 1 MOLY.
- 2-½ CR., ½ MOLY., ¾ SIL.
- 3 CR., ½ MOLY., 1-¼ SIL.
- 5 CR., ½ MOLY., 1-½ SIL.
- 3 CR., 1 MOLY.
- 5 CR., ½ MOLY.
- 5 CR., ½ MOLY., TITANIUM
- 7 CR., ½ MOLY.
- 5 CR., ½ MOLY., COLUMBIUM
- 8 CR., 1 MOLY.
- 9 CR., 1 MOLY.
- 12 CR., ALUMINUM
- 17 CR.
- 18-8
- 18-8 TITANIUM
- 18-8 COLUMBIUM
- 18-8 MOLYBDENUM
- 25-20
- LOW CARBON
- LOW CARBON, ½ MOLY.
- LOW CARBON, 1 MOLY.
- ½ CR., ½ MOLY.
- 1-¼ CR., ½ MOLY.

FOR STILL TUBES • CONDENSER TUBES
HEAT EXCHANGER TUBES • REFINERY PIPING

HERE at NATIONAL—the world's largest producer of tubular products — we have gathered a vast amount of interesting information on the performance of various steel analyses under practically every conceivable condition.

Much of this data comes from experiments and tests in our own modern laboratories. Additional volumes of it were accumulated through the close and constant observation of the experiences of refineries throughout the country with varying conditions of temperature, pressure, corrosion, and exposure.

Out of all this research and study have come important developments in tubing steel which enable NATIONAL to now offer you Seamless Still Tubes, Condenser Tubes, Heat Exchanger Tubes, and Refinery Piping in 25 different analyses. Each of these 25 different analyses has been performance-proved to meet the specific conditions of corrosion and oxidation for which it is recommended.

Yes, bring your problems to NATIONAL. No other company is better equipped to help you solve them. NATIONAL's Staff of Tubing Specialists will work closely with your own engineers to see that you get just the right tubes and piping for your particular requirements.

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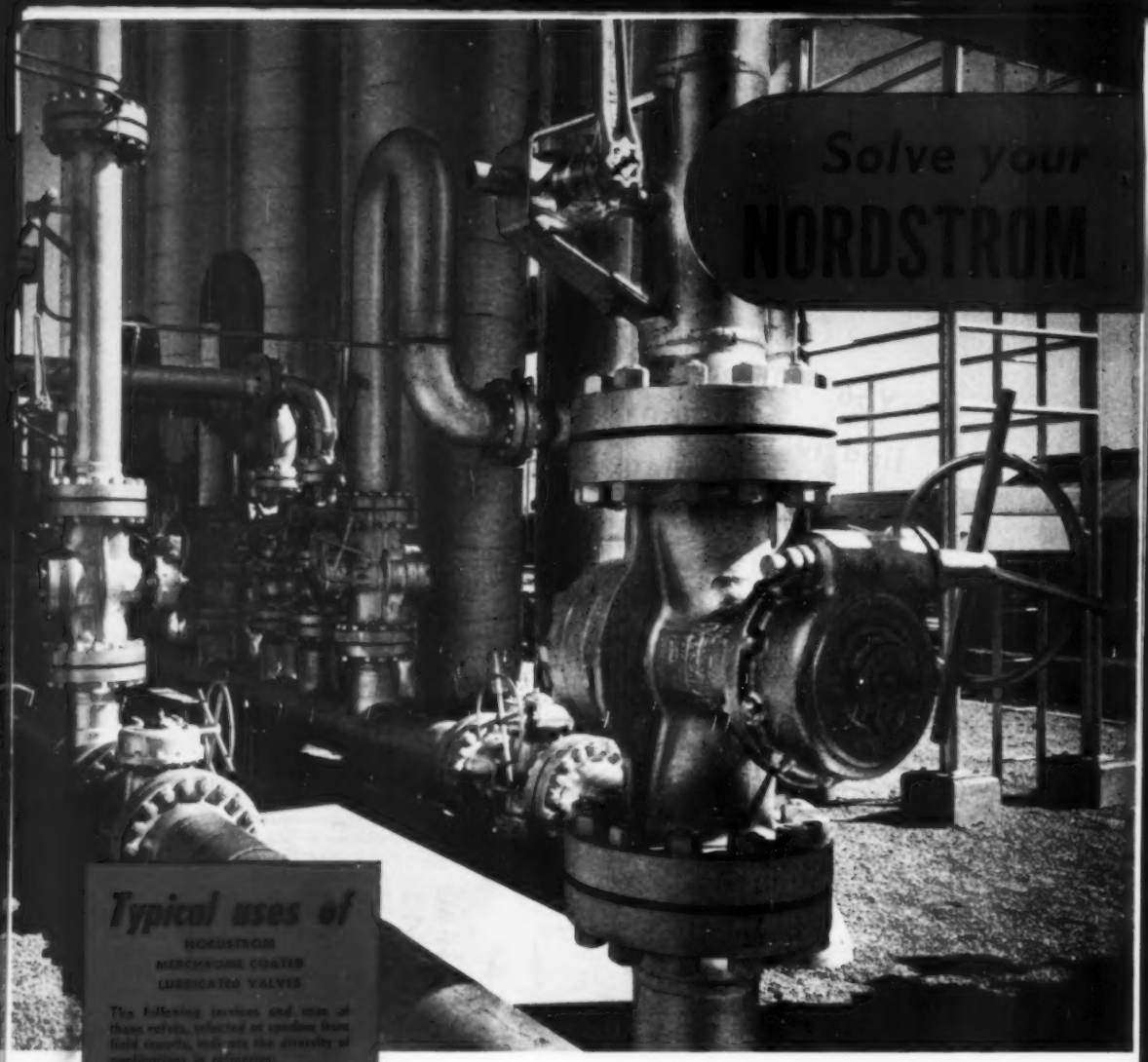
NATIONAL SEAMLESS PIPE AND TUBES

UNITED STATES STEEL



Typical uses of

NORDSTROM
MERCHROME COATED
LUBRICATED VALVES

The following services, and sizes of these valves, selected at random from field reports, indicate the diversity of applications in refineries:

Butadiene catalytic polymerization at temperatures up to 1050 F. and over.

Iso-butane-propane mixture, 500 F.

Catalytic polymerization plant handling hydrocarbon vapors at 425 F. and 1050 lb.

Fluid catalytic cracking at 1000 F. and above.

Hot corrosive tar at 820 F.

Hot oil at 950 F.

Hydrocarbon gas above 1000 F.

Light oil and heavier still residue at 900 F.

Naphtha vapors at 600 F.

Oil slurry at 650 F. in powdered catalyst service.

Oil vapors to 1000 F.

Crude topping unit to 675 F.

REFINERIES have actually become chemical processing plants. Complex combinations of conditions involve temperature, pressures, erosive and corrosive characteristics of line contents. Refinery operations impose many conditions that only a lubricated plug valve can successfully meet.

The most stringent specifications are best met by installation of Nordstrom Merchrome coated valves. Some refinery units could not successfully function without them.

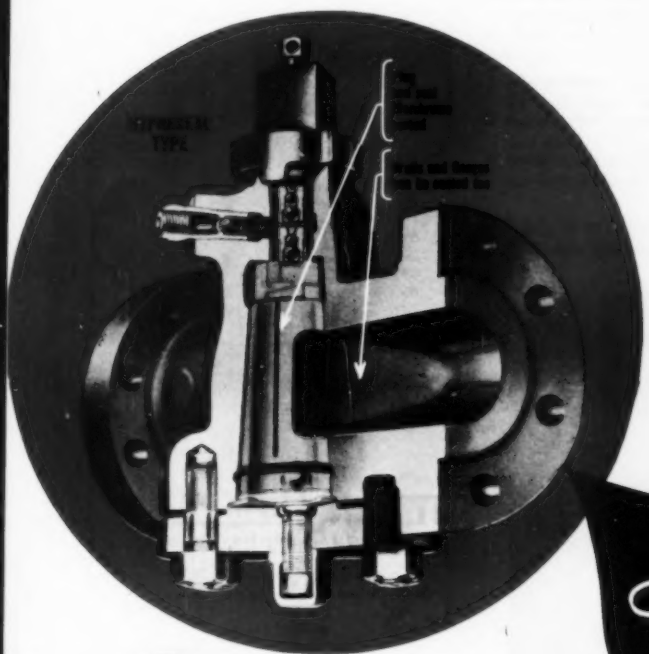
corrosion and abrasion problems with

MERCHROME COATED VALVES

Steel valves with hard-faced protection

Merchrome coating, an exclusive Nordstrom development, makes possible the use of standard types of steel for basic plug valve construction. It provides internal valve surfaces of alloys suitable for unusually severe line fluid conditions. Its application permits the use of a steel body to maintain the proper strength, ductility and machinability, protected with a heavy coating of special alloy, welded to the surface of the plug, the body, or both, and finished to an accurate fit. Several types of coating material are used to meet various combinations of temperature, abrasive and chemical activity.

The tapered plug and body surfaces are coated with an extremely hard, non-galling alloy which has a very low coefficient of friction, and is resistant to most types of corrosion.



MERCHROME COATING PROVIDES A COMBINATION OF ADVANTAGES

Merchrome coating makes possible the construction of valves of non-hardenable metals such as stainless steel, which have desirable physical and chemical properties but which are subject to galling action. Thus Nordstrom can provide valves that have proper structural and chemical characteristics and hard-faced surfaces, plus the basic advantages of the Nordstrom lubricated plug design.

FOR CONTINUED DEPENDABILITY USE THE RIGHT LUBRICANT—NORDCOSEAL

Use of genuine Nordcoseal lubricants insures the most dependable valve operation. These lubricants are the result of years of research, test and use in every conceivable refinery operation. Different grades are available for specific conditions. Don't use substitutes if you want the most successful operation.

The Nordstrom engineering staff is at your service to assist you in making the proper selection of valves for specific refinery applications and to set up the most effective and economical maintenance programs.

KEEP UPKEEP DOWN

Nordstrom LUBRICATED VALVES

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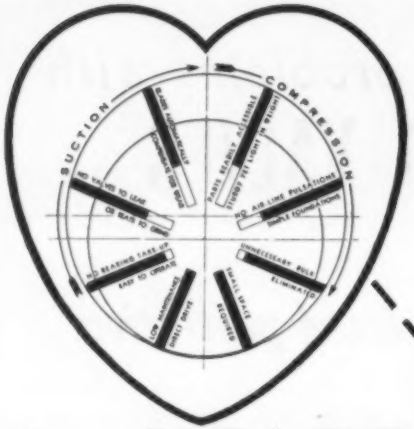
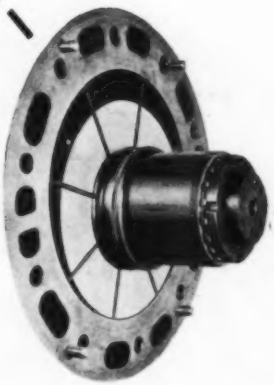


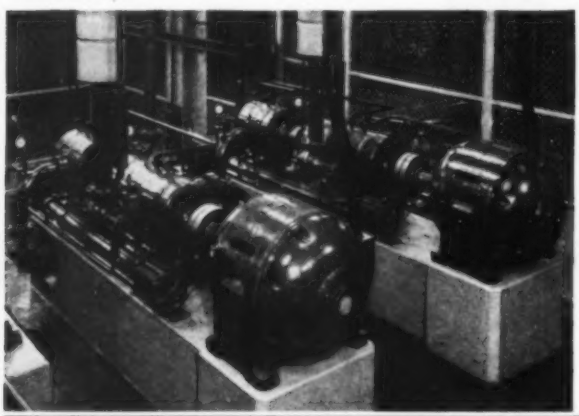
the HEART of the *Fuller Rotary Compressor*

There are innumerable reasons why Fuller Rotary Compressors are being installed in many fields of industry. The one outstanding factor is, "The Heart of the Rotary", the inherent advantage peculiar to continuous motion, with the consequent absence of pulsations and vibration; minimum number of working parts. This unequalled mechanical simplicity provides for sustained efficiency, and relief from maintenance annoyance and labor costs.

Their extraordinary capacity, with relation to size, makes them readily adaptable for use where space is limited; also installation of separate compressors at the point of air consumption. In other words: "Spot your compressors where you need the air". Such installations offer many advantages and savings when compared with a large central compressor plant, with its attendant network of plant air lines and consequent losses.

Fuller Rotaries are built for capacities to 3300 c.f.m., 125-lb. pressure. Write for Bulletin C-5, which fully illustrates and describes these machines.



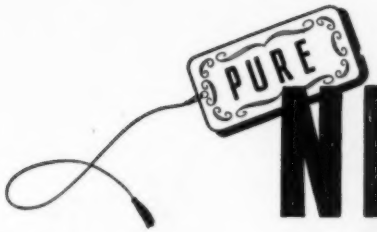


FULLER COMPANY
CATASAUQUA—PENNSYLVANIA

Chicago 3 - 120 So. LaSalle St.
San Francisco 4 - 420 Chancery Bldg.

A LIFETIME OF NEW MACHINE EFFICIENCY

C-183



NICKEL

Sheet, Strip, Rod, Wire, Tubing, Clad-steel, Castings.

Its practical cost astonishes users almost as much as its distinctive characteristics

CHEMICAL COMPOSITION

The nominal composition of commercially pure wrought Nickel is:

Nickel*	99.4%
Copper	0.1
Iron	0.15
Manganese	0.2
Silicon	0.05
Carbon	0.1

**Including cobalt*

PHYSICAL CONSTANTS

Specific Gravity	8.89
Density, lb. per cu. in.	0.321
Melting Point	2615-2635°F. / 1435-1445°C.
Specific Heat at (80-212°F.)	0.130
Heat Expansion Coefficient at (80-212°F.), per °F.	0.0000072
Thermal Conductivity at (80-212°F.), Btu/sq. ft./hr./°F./in.	420
Electrical Resistivity at 32°F., ohms/cir. mil. ft.	63
Temperature Coefficient of Electrical Resistivity per °F.	0.0022-0.0028
Modulus of Elasticity in tension, psi	30,000,000
in torsion, psi	11,000,000
Poisson's Ratio	0.31

MECHANICAL PROPERTIES

The following figures for Standard Cold Rolled Sheet are typical, though the figures will vary for different forms and tempers.

Tensile Strength	55,000-80,000 psi
Yield Strength (2% offset)	15,000-45,000 psi
Elongation in 2 in.	50-35%
Rockwell B Hardness	40-70

AVAILABLE FORMS

Wire	Bar	Plate	Pipe
Rod	Angles	Sheet	Strip

Seamless and Welded Tubing
Sand and Precision Castings
Clad-Steel Plate and Strip Welding Rods

It is a strange and interesting metal, Pure Nickel. A kin of both the base metals and the precious metals. Among all the elements, no other metal possesses its unique combination of so many different and uncommon properties.

- It is highly resistant to corrosives that destroy many other metals—alkalies, many acids, salts, organic compounds, fumes.
- It has mechanical properties like those of structural steel.
- Yet it is so ductile that it can be worked into the most intricate and delicate shapes that are practical in metal.
- It protects the purity of sensitive foods, beverages and pharmaceuticals against contamination.
- It often provides a faster rate of heat transfer than metals with equal heat conductivity.
- Its special electronic properties make it a standard metal for electronic uses.
- It offers rare electrical and magnetostrictive characteristics that often give theoretical ideas a birth of practical value.
- It can be exposed to temperatures ranging into yellow heat and even hotter in the absence of sulphur.
- At sub-zero temperatures its strength increases without change in ductility and toughness.
- It is a standard metal for the cladding of steel, and as a base for gold, palladium and silver-clad products.

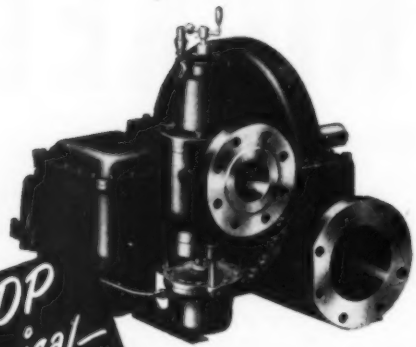
And one of the most valuable of all its features is the fact that Pure Nickel is a practical metal at a practical price.

Does it stimulate an idea of how you may find an easy answer to a difficult problem?

Our technical bulletin "Engineering Properties of Nickel" gives the important facts you want. It's yours for the asking.

The International Nickel Company, Inc.

67 Wall Street, New York 5, N. Y.



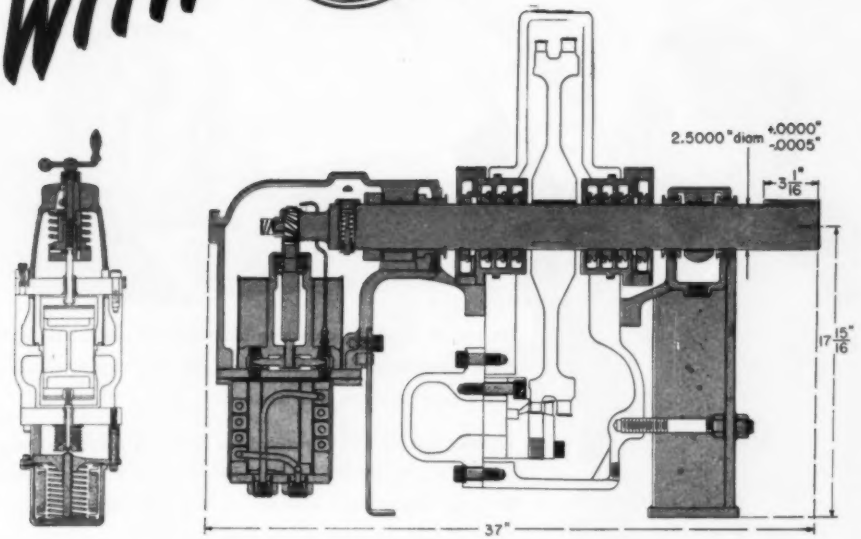
HERE'S HOW YOU SAVE

SAVE ON SPARE PARTS because of high degree of interchangeability of the new Type DP line. (Cross-section drawing shows parts interchangeable on all frame sizes.)

You can reduce your spare parts inventory with this standard kit, containing parts applicable to *all* standard Type DP turbines. With this set of packaged spares you save 75% of price of comparable set of loose spares for previous designs.

With the DP you save money on first cost too. Only G.E. offers hydraulic governing (30% adjustable speed range) on a standard turbine — at no extra cost.

WITH GE TURBINES



PARTS IN COLOR INTERCHANGEABLE ON ALL FRAME SIZES

SAVE TIME when installing DP turbines or when re-locating them in your plant. (Drawing shows dimensions common to all frame sizes.) Standard shaft height permits you to use a fixed mounting height on all your turbine drives. Standardization of the DP saves time on deliveries too — shipment time is approximately 20 weeks.

When it comes to alignment, you'll appreciate the DP's center-line support — now standardized on all frame sizes. Center-line support eliminates mis-alignment resulting from expansion from normal heating.

SAVE TROUBLE because of superior design features of the new Type DP — features such as: totally enclosed governing system protected in an oil atmosphere against rusting and sticking (particularly a problem on standby units); nonsparking overspeed trip, suitable for explosive atmospheres; new long-life solid-backed bearings; Monel-sprayed shaft at packings to eliminate corrosion; positive pressure lubrication; balanced valve design, and many other improvements to reduce maintenance.

The new Type DP is not a "standard turbine" for a narrow range of ratings only, but a standardized *line*, in ratings from 10 to approximately 1200 hp, speeds from 1000 to 5000 rpm. Thus, if your turbine drives fall within this wide range, you can save money — time — and trouble — by standardizing on the Type DP. For full information get in touch with your G-E representative. ***Apparatus Department, General Electric Company, Schenectady 5, N. Y.***

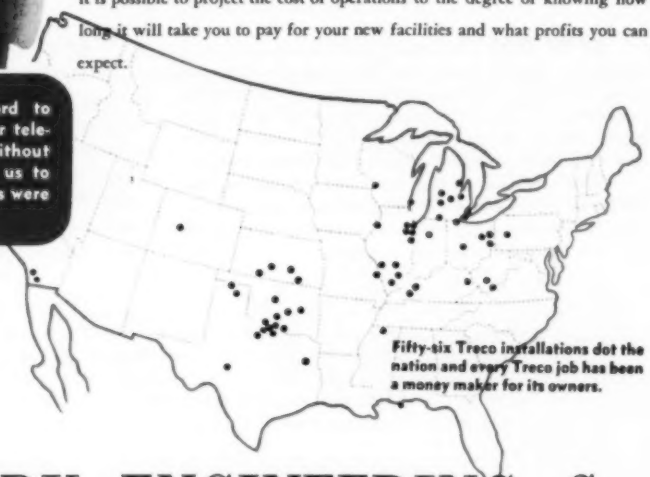
GENERAL ELECTRIC

You Can Build NOW . . . . . Profitably

The cost of practically everything used in refinery construction is going up. Prices may continue to rise; but *you can still afford to build or remodel and have a quick return on your investment.*

Assuming that the costs of material and labor may continue upward, *there is a known point to which you can safely project your costs* of construction. Treco can show you how much you can afford to spend and how you can define all costs, entering into the project. With all the variables accounted for; with the cost of construction, materials, labor and crude determinable it is possible to project the cost of operations to the degree of knowing how long it will take you to pay for your new facilities and what profits you can expect.

Treco can show how you can afford to build or remodel NOW. Wire, write or telephone to arrange for a conference, without obligation to you. Our planes enable us to serve you as completely as if our offices were in your city.



Fifty-six Treco installations dot the nation and every Treco job has been a money maker for its owners.

TRECo

The REFINERY ENGINEERING Co.

Phone 5-5511 Tulsa, Oklahoma

Everything

from stud bolts

to furnaces

That's covering quite a lot of ground. But our refinery stocks are actually so large that you can almost always get what you want merely by phoning us.

Studs and nuts, valves, fittings, hose and packing, tubular goods, expansion joints, gages, thermometers, regulators . . . these and many other commonly-needed products are available at your nearest Bethlehem Supply store. And, if it's an engineered item—such as a pump or a furnace—we can help you determine the unit that will do the best job; save you the time and expense of running it down yourself.

Maybe all you need today is some studs. Or maybe you're figuring something big, like an Iso-Flow heater. Whether it's big or little or in between, get Bethlehem Supply on the job. We'll shift into gear mighty fast.

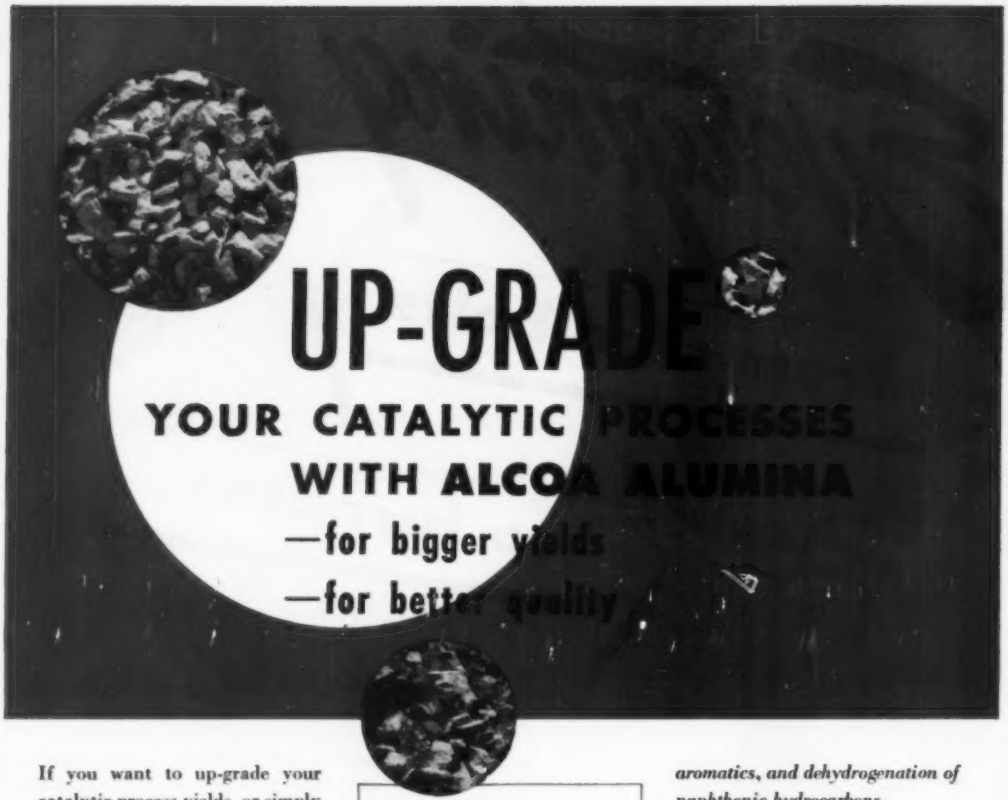
BETHLEHEM SUPPLY COMPANY

General Offices: 21 E. Second St., Tulsa, Okla.

Subsidiary of Bethlehem Steel Corporation

BETHLEHEM STEEL

GHQ FOR REFINERY SUPPLIES



If you want to up-grade your catalytic process yields, or simply reduce losses from contamination and side reactions, you'll find it advantageous to insist on ALCOA Aluminas for your Al_2O_3 catalysts and catalyst supports.

ALCOA Aluminas are uniform in structure and chemical purity . . . stable at elevated temperatures . . . have high resistance to erosion and crushing . . . and are moderate in cost. Typical conversions for which ALCOA Aluminas are used include: *Aliphatic hydrocarbons into aromatics, and dehydrogenation of naphthenic hydrocarbons.*

★ **ALCOA *Activated* Alumina is preferred for many reactions because of its high adsorptive properties and extremely large surface area.**

★ **ALCOA *Tabular* and other forms of Alumina are preferred for certain reactions where hardness and extremely high purity are relatively more important than maximum surface area.**

For top quality, specify ALCOA Aluminas for catalysts and catalyst supports. You'll get more efficient, uniform reactions and end-products of higher purity. We'll gladly send you samples and further information.

ALUMINUM COMPANY OF AMERICA,
CHEMICALS DIVISION, 1963
Gulf Building,
Pittsburgh 19,
Pennsylvania

ALCOA

ALCOA CHEMICALS
ALUMINAS AND FLUORIDES

ACTIVATED ALUMINAS • CALCINED ALUMINAS • LOW SODA ALUMINAS • TABULAR ALUMINAS • HYDRATED ALUMINAS
ALUMINUM FLUORIDE • SODIUM FLUORIDE • SODIUM ACID FLUORIDE • FLUOBORIC ACID • CRYOLITE

many brains are needed

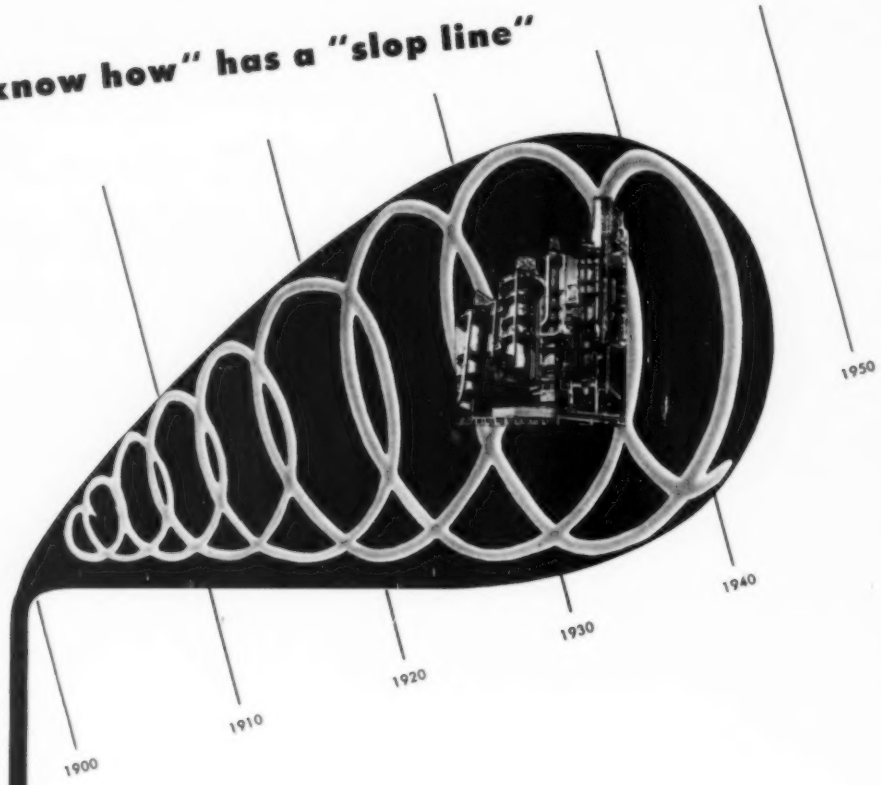
process design
mechanical design
drafting
estimating
purchasing
accounting
inspection
fabrication
construction

. . . and many brains—many functions—many details must be coordinated in the production of a process unit, a petroleum refinery, a complete chemical plant—a satisfied customer.

FOSTER WHEELER CORPORATION

165 BROADWAY, NEW YORK 6, NEW YORK

"know how" has a "slop line"



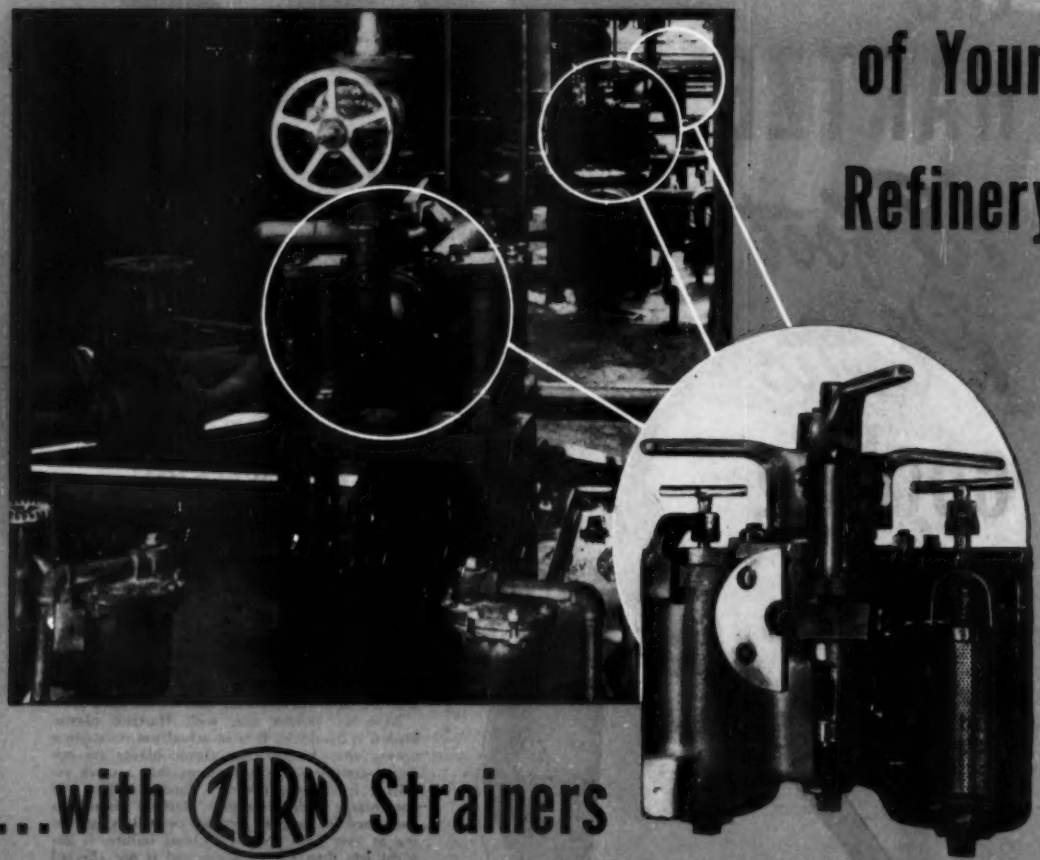
A live, active and serviceable "know how" is one which is continually undergoing revision in the light of current knowledge—the obsolete must be drawn off.

Foster Wheeler's "know how", the refined concentrate of nearly 50 years' engineering experience is an invaluable asset in the planning and building of process units, petroleum refineries and complete chemical plants.

FOSTER WHEELER CORPORATION

165 BROADWAY, NEW YORK 6, NEW YORK

Protect the Operating Equipment of Your Refinery



...with ZURN Strainers

STRAINERS are vital in the protection of refinery equipment. "Oilwell" carries in stock the following types of ZURN Strainers:

Y STRAINERS . . . will handle gases containing a small percentage of solids. Suitable for fluid applications if the solid content is particularly low. For intermittent flow only.

ANGLE TYPE STRAINERS—For high pressures, particularly for vapor, steam or gas services.

DUPLEX STRAINERS—Used where continuous operation is a necessary requirement. Either chamber can be cleaned while the pipe line maintains normal flow.

VISIBLE TUBE STRAINERS—This is a duplex strainer that permits visual inspection by operator.

SINGLE STRAINERS—For handling fluids carrying an appreciable quantity of solids. Suitable for intermittent flow.

Let "Oilwell" assist you with your strainer problems.

OIL WELL SUPPLY COMPANY

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Division Offices — CASPER, WYOMING
COLUMBUS, OHIO . . . DALLAS, TEXAS
HOUSTON, TEXAS . . . TULSA, OKLAHOMA
LOS ANGELES, CALIFORNIA

USS "OILWELL"

UNITED STATES STEEL

the HARTZELL *18 foot Plastic* cooling tower fan

NOW

RESISTS CORROSION
REDUCES VIBRATION

In 1941 Hartzell introduced a material—Hartzite plastic—which provides amazing resistance to corrosion damage. It also dampens vibration and resists damage from it.

In 1941 Hartzite plastic was a new material. In 1949 it is one which has thoroughly proved itself in cooling tower fans of from 10 to 16 feet diameter. Where it has been tried it has been specified regularly on following fans for the same user.

Now an 18-foot fan, with Hartzite plastic blades, is available. It is in actual use on cooling towers *now*. Its Hartzite plastic blades are not "notch-conscious," which means that a crack resulting from contact with a foreign object will not enlarge under vibration. Hartzite plastic has been used for years in airplane propellers, operating at very high speeds, without failure. It absorbs less than 1% of water and is not affected by 250-degree heat or minus-40-degree cold. It is practically impervious to most acids, alkalies, salt water and weathering.

We build a full range of cooling-tower fan sizes, from 3 to 18 feet diameter. Blades of fans smaller than 10 feet are of cast aluminum alloy—ideal in that size range.

Hubs of all Hartzell cooling-tower fans possess strength many times greater than the minimum essential. Pitch of all blades can easily be changed to compensate for changes in air needs or in atmospheric conditions.

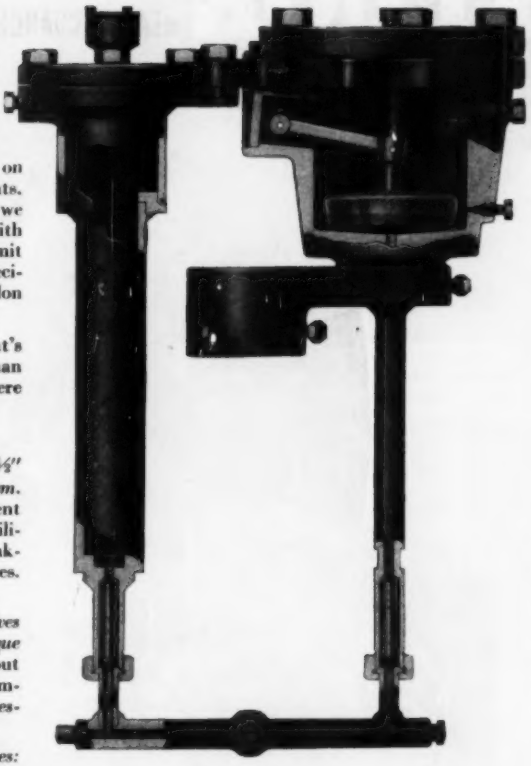
Send for our new Bulletin 1502, with complete cooling-tower fan data. And make sure that specifications for the cooling tower you buy or build call for a Hartzell fan or fans. There's no better insurance of top performance *and* long life.

HARTZELL PROPELLER FAN CO.
DIVISION OF CASTLE HILLS CORPORATION
PIQUA, OHIO

PROPELLER TYPE FANS AND BLOWERS • ROOF VENTILATORS • UNIT HEATERS • ENGINEERING OFFICES IN PRINCIPAL CITIES

You asked for a better MERCURY MANOMETER

HERE it is! The new Taylor "1500" Mercury Manometer with "Floating Power" grew from closely coordinated, highly specialized work by our Research, Engineering, and Development departments based on Industry's advanced requirements. To give it "Floating Power" we first built in an extra-big float with extra-long travel. And to transmit this great power we added a precision-ground shaft with *Teflon bearings which "float" the power through to the pen.



RESULT—we now offer you a Mercury Manometer that's ready to step in wherever you need something *better* than present differential pressure measuring instruments. Here are a few features:

1. HIGH ACCURACY. Inherent straight-line calibration.

2. POSITIVE ACTUATION—High energy output. (a) *Big 3½" float.* (b) *Long float travel—1".* (c) *Simple lever system.* (d) *Teflon in pressure-tight bearing surfaces* for efficient use of power. Teflon bearings, micro-finished shaft, silicone lubricant give unprecedented performance—leakless, with negligible friction under high working pressures. (e) *Jewelled thrust bearing.*

3. DEPENDABLE PERFORMANCE. (a) *Submerged check valves* give positive shut-off in event of overrange. (b) *Unique damping valve* adjustable under full pressure without leakage. (c) *Ample room* in mercury chambers to accommodate surges or pulsating flows. (d) *Teflon holds pressure,* yet lets shaft turn freely, giving long service.

4. GREAT ADAPTABILITY. (a) *Six interchangeable range tubes:* 10", 20", 50", 100", 200" and 400" of water. (b) *Tubes easily changed* in field without piping alterations. (c) Both side and top pressure connections. (d) *Two Manometers* can be mounted on back of single case for recording two Flows or for Ratio-Flow control.

5. EASE OF MAINTENANCE. (a) *Low pressure chamber cover* permits easy access to float and lever arm during calibration. (b) *Entire pressure-tight bearing* easily and economically replaced.

Ask your Taylor Field Engineer, or write for bulletin 98182. Taylor Instrument Companies, Rochester, N. Y., or Toronto, Canada.

*Teflon—synthetic plastic used in bearing surfaces—conforms to stainless steel shaft. Also minimizes friction. Because Teflon is inert to most industrial chemicals, bearing surfaces are generally unaffected by corrosion.

Taylor Instruments
MEAN
ACCURACY FIRST
IN HOME AND INDUSTRY

Instruments for indicating, recording and controlling temperature, pressure, humidity, flow and liquid level.

WHEN WATER IS
HOT...BAD...or EXPENSIVE

FLUOR FIN·FAN

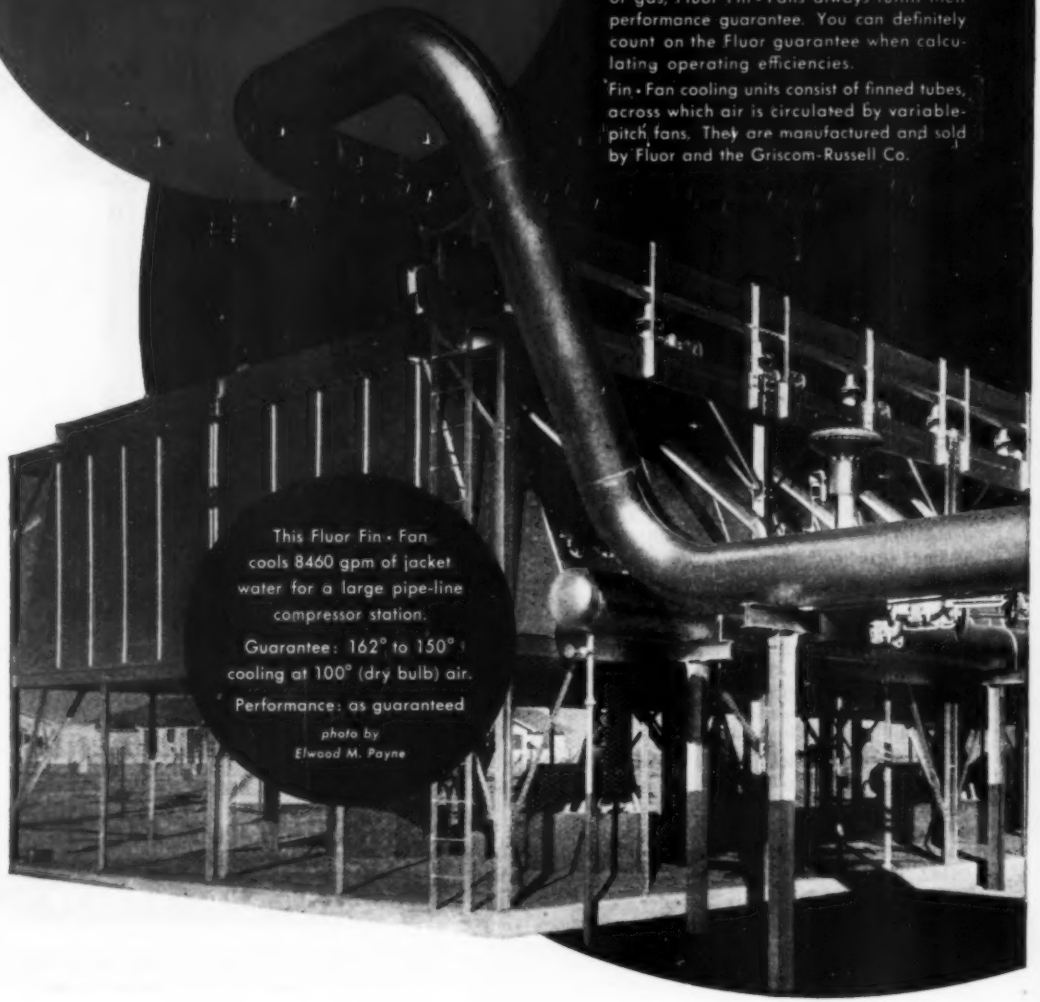
HEAT EXCHANGERS
COOL AT LOWEST COST

Hot! Bad! Expensive! When the temperature of the fluid to be cooled is much higher than ambient air temperature, when available water has bad scaling characteristics, or when make-up water is scarce and expensive, then you should definitely investigate the use of a Fluor Fin • Fan heat exchanger.

Guaranteed Performance

Whether used to cool process liquids, water, or gas, Fluor Fin • Fans always fulfill their performance guarantee. You can definitely count on the Fluor guarantee when calculating operating efficiencies.

Fin • Fan cooling units consist of finned tubes, across which air is circulated by variable-pitch fans. They are manufactured and sold by Fluor and the Griscom-Russell Co.



This Fluor Fin • Fan cools 8460 gpm of jacket water for a large pipe-line compressor station.

Guarantee: 162° to 150° cooling at 100° (dry bulb) air.

Performance: as guaranteed

photo by Elwood M. Payne

BE SURE WITH FLUOR

FLUOR

THE FLUOR CORPORATION, LTD.

Los Angeles 22 • NEW YORK • PITTSBURGH
HOUSTON • KANSAS CITY • BOSTON • TULSA
SAN FRANCISCO

Aerator Towers

Counterflo Towers

Pulsation Dampeners

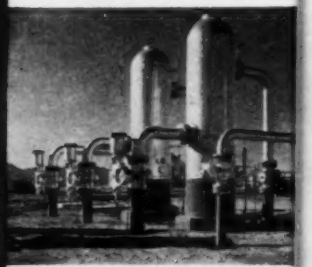
Gas Cleaners

Mufflers

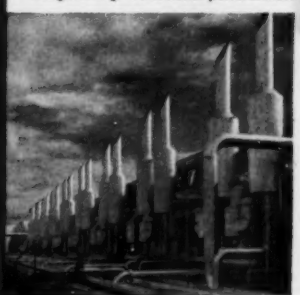
Fluor Aerator cooling towers have distinctive economy features and are most practical in certain cooling applications.

Fluor Counterflo induced-draft cooling towers are a standard of industry for most water-cooling applications. They deliver "colder water cheaper."

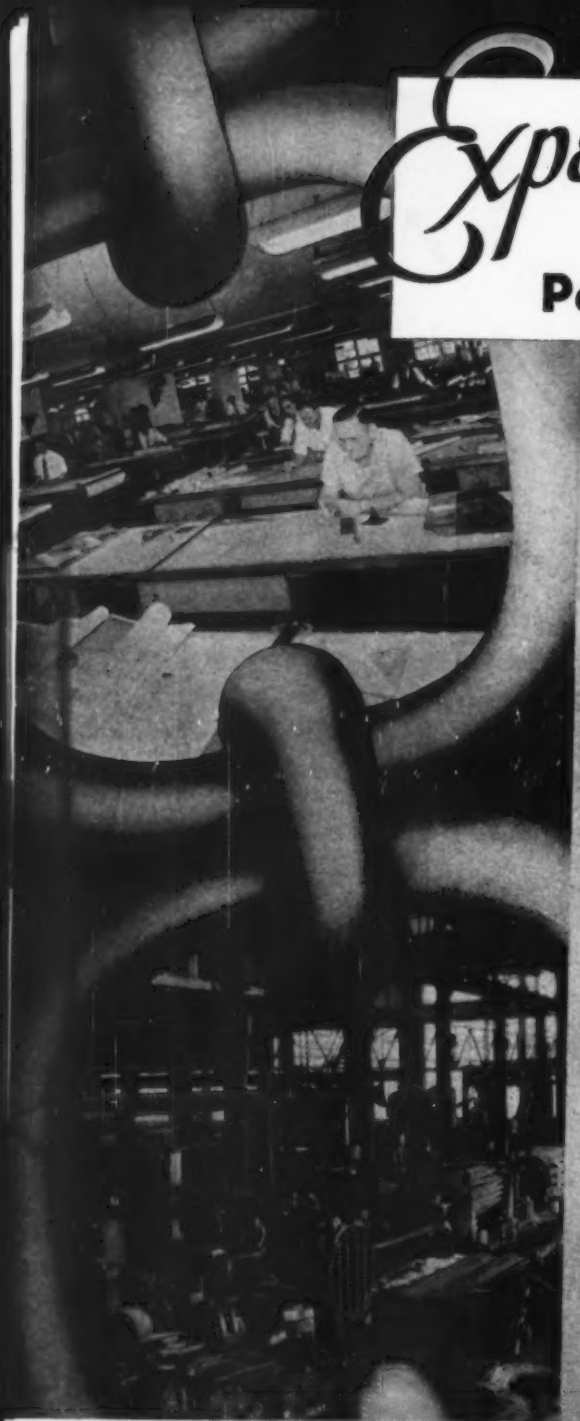
Fluor pulsation dampeners remove destructive vibrations and instrument irregularities caused by pulsative gas flow.



The Fluor gas cleaner, already well-known for efficient cleaning, has been redesigned to give still better performance.



Fluor mufflers, redesigned to incorporate pulsation-dampener principles, reduce exhaust-line noises to less than the mechanical noises of the compresser room.



Experience that Links Our Facilities with Perfection in Production

Enables Us to Offer Unexcelled Service in Creating *New*

MADE-TO-ORDER REFINERY AND CHEMICAL PLANT EQUIPMENT

•

Specially Fabricated

PLATE WORK

•

PRESSURE VESSELS

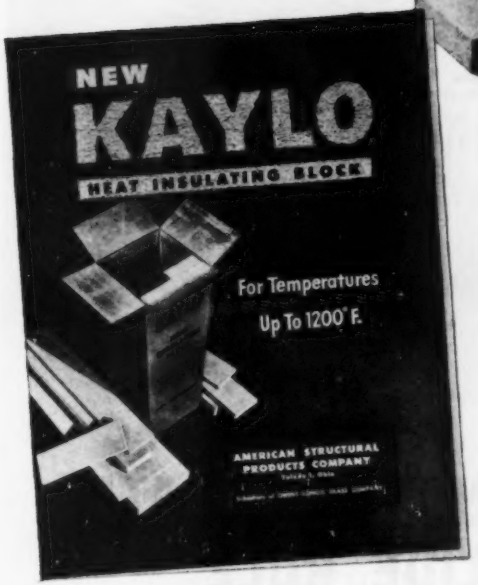
SUN SHIPBUILDING and DRY DOCK COMPANY

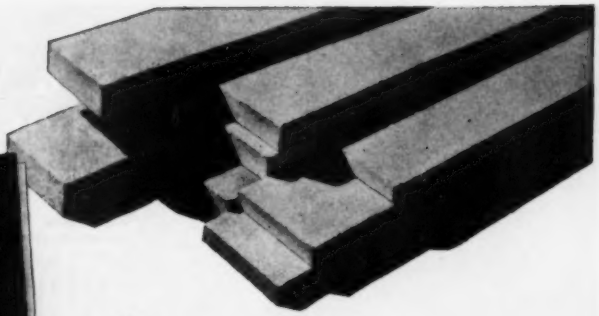
CHESTER PENNA.

Since 1916

USMM

JOIN



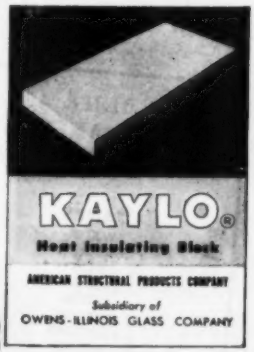


Now ready KAYLO®

LIGHT DENSITY Heat Insulating Block

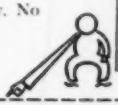
BE SURE you get the facts about Kaylo Heat Insulating Block—the remarkable new insulation that's strong, lightweight and highly efficient.

Now in production in a new manufacturing plant, Kaylo Heat Insulating Block is being shipped in quantity for the first time. It has been in pilot plant manufacture for several years, and thousands of square feet of it are serving efficiently on typical heat insulation applications.



SEND COUPON
For Literature or Sample

Available in standard sizes, this new heat insulating block combines many valuable properties you should know about. Get complete information by mailing coupon below. No obligation, of course.



AMERICAN STRUCTURAL PRODUCTS COMPANY
Dept. F-425, P.O. Box 1035
Toledo 1, Ohio

Gentlemen:

Please send: ☐ Free illustrated booklet, "Kaylo Heat Insulating Block."
☐ Free sample of Kaylo Heat Insulating Block.
☐ Have representative call.

Name_____

Address_____

City_____ **County**_____ **State**_____

THINGS YOU CAN'T CALCULATE ON YOUR SLIDE RULE

OTHER GENERAL AMERICAN EQUIPMENT

TANKS
WATER
GASOLINE
ACID
PROPANE
BUTANE
CHLORINE
BLENDING
MIXING
CRUDE

TOWERS
ABSORBER
BUBBLE
FLASH
VACUUM
FRACTIONATING
PRESSURE

DEWAXING FILTERS
TURBO-TREATERS
STEEL PLATE FABRICATION
WIGGINS ROOFS

Engineering problems solved in the laboratory are problems no longer — yet in steel and alloy plate fabrication there are factors where the right answers yield more readily to common sense than to the slide rule.

The integration of planning, design, fabrication and erection into one responsibility—the full utilization of laboratory and X-ray equipment—the desire to maintain an established reputation painstakingly built up over the years — the "know how" born of operating the world's largest privately owned tank car lines—all of these things are considerations you can't possibly calculate on your slide rule.

As a matter of fact, from the very first moment you begin to think about steel and alloy plate fabrication, it's common sense to think about the General American Plate & Welding Division.

GENERAL AMERICAN TRANSPORTATION CORPORATION

Plate & Welding Division

SALES OFFICE: 10 East 49th St., Dept. 980, New York 17, N. Y.

WORKS: Sharon, Pa., East Chicago, Ind.

TRADE MARK

OFFICES: Chicago, Cleveland, Louisville, Orlando, Pittsburgh, St. Louis, Salt Lake City, Sharon, Washington, D. C.

MEASURING SATISFACTORY PERFORMANCE

. . . IN EVERY TEST!

QUAKER PACKINGS ARE "PRE-TESTED" TO ASSURE PERFECT FIT, LONG LIFE, MAXIMUM EFFICIENCY

Packings to be efficient must be perfect in fit . . . must form a tight seal in pumps, flanges, valve stems, piston rods to prevent leaks . . . must be of exact quality to meet the operating requirements of specific conditions.

That's why Quaker Packings are "pre-tested." Carefully calipered for size and fit . . . painstakingly checked for quality. Above we see the final test, one of many pre-tests Quaker Packings must go through before they are ready for usage. Tests that are safeguards against costly leaks, troublesome shutdowns, loss of production.

There's a Quaker packing for every type of service—water, air, gas, oil, acids at extreme temperatures . . . all pre-tested for better performance.

HOSE THAT LASTS

. . . because it has been pre-tested to stand pressure and resist wear. Quaker Hose is available for use with air, water, steam, volatiles, acids and gases.

FOR PEAK HORSEPOWER

Quaker belts are pre-tested for every industrial need . . . belts of all kinds that assure peak efficiency under all operating conditions.

QUAKER RUBBER CORPORATION

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QUAKER

RUBBER PRODUCTS

•

QUAKER RUBBER CORPORATION PHILADELPHIA, PA. QUALITY SINCE 1918

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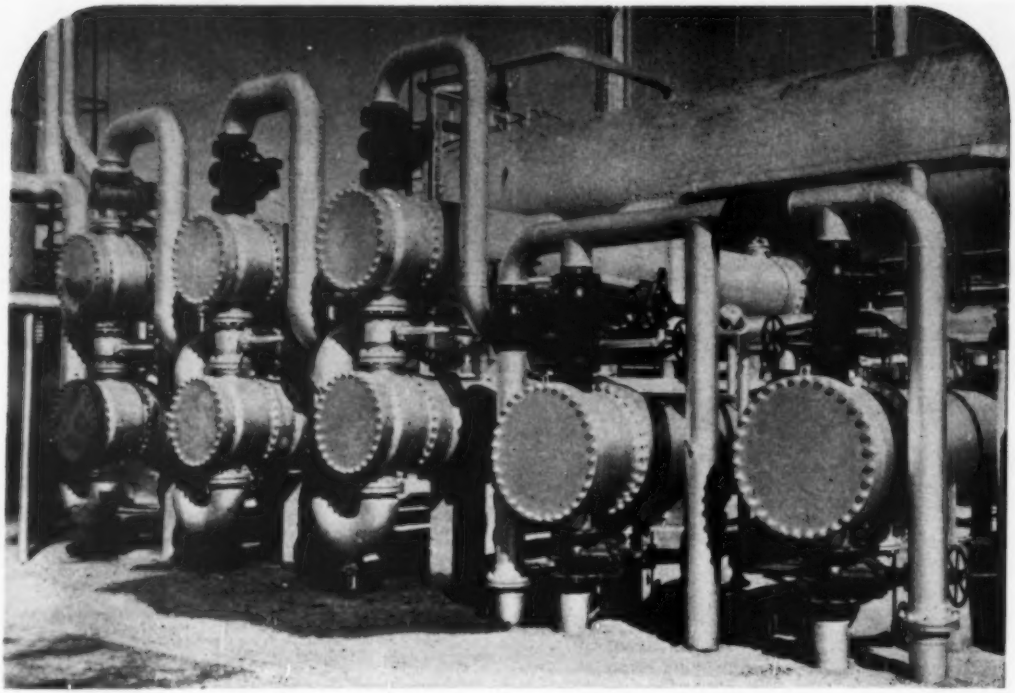
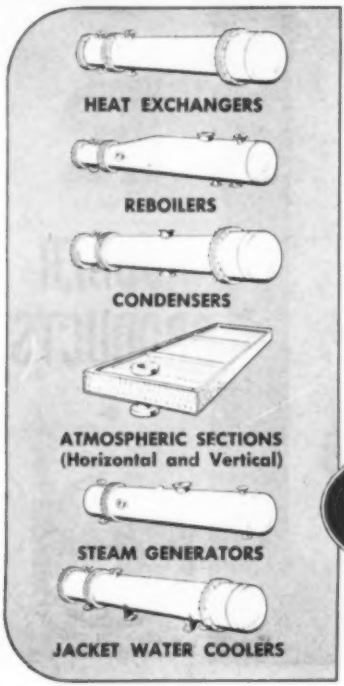


Make sure your Heat Exchangers are



"EFCO Engineered"

● Heat exchangers by EFCO specialists are carefully designed to meet *your* specific requirements. EFCO heat exchangers give you long, trouble-free operation plus the extra advantages of lasting tightness, optimum heat exchange, and minimum maintenance costs.

ENGINEERS & FABRICATORS, INC.
P. O. Box 7395 Houston 8, Texas

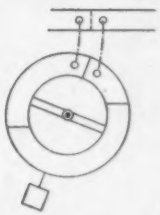
EFCO

HEAT TRANSFER EQUIPMENT

Ring Balance Meters, SURE- but be sure they are

HAGAN Ring Balance

this isn't new



The ring balance principle is old, and flow meters based on this principle have been built both in this country and in Europe. But all of them, except the meter which Hagan now builds, had features which largely offset the advantages inherent in the ring balance principle.

this is new

One weakness of other ring balance type meters is that connecting lines, particularly when pressures are high, tend to restrict ring motion. In Hagan Ring Balance meters, this difficulty is completely eliminated in a most simple and direct fashion—by the use of S-shaped connecting tubes. This feature is patented and is found only in these meters.

and this is new-

Adjustment of this spring by means of a simple range screw permits a change of as much as 7 to 1 in differential pressure. Even at low flows, this unique spring resistant system gives high accuracy in the conversion of differential head to pen movement. Patent is pending.

and so is this

The integrator, another patented feature of Hagan Ring Balance meters, is an independent unit easily added to or removed from a standard meter assembly. It is simple in design; accurate between 2% and 100% of meter range; calibrated by a single adjustment; and easily checked, either under test conditions or with the meter in service.

HAGAN CORPORATION

RING BALANCE FLOW AND PRESSURE INSTRUMENTS
THRUSTORQ FORCE MEASURING DEVICES
BOILER COMBUSTION CONTROL SYSTEMS
METALLURGICAL FURNACE CONTROL SYSTEMS

For full information on Hagan Ring Balance Flow Meters, just fill out and mail the coupon below. Hagan Corporation, Hagan Building, Pittsburgh 30, Pa.

HAGAN CORPORATION
HAGAN BUILDING, PITTSBURGH 30, PA.

Please send me your Ring Balance Meter Bulletin 2M48.

NAME _____

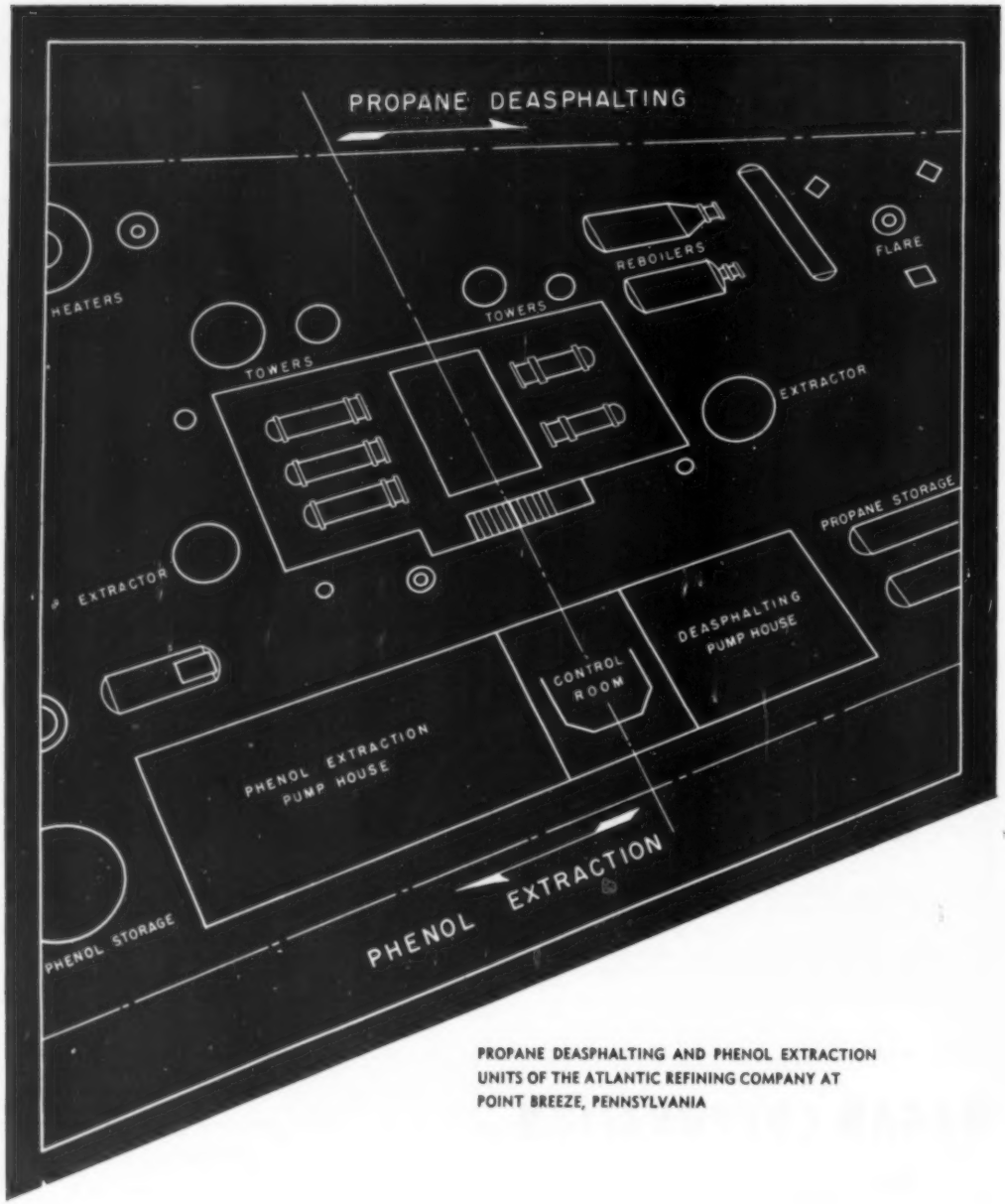
POSITION _____

COMPANY _____

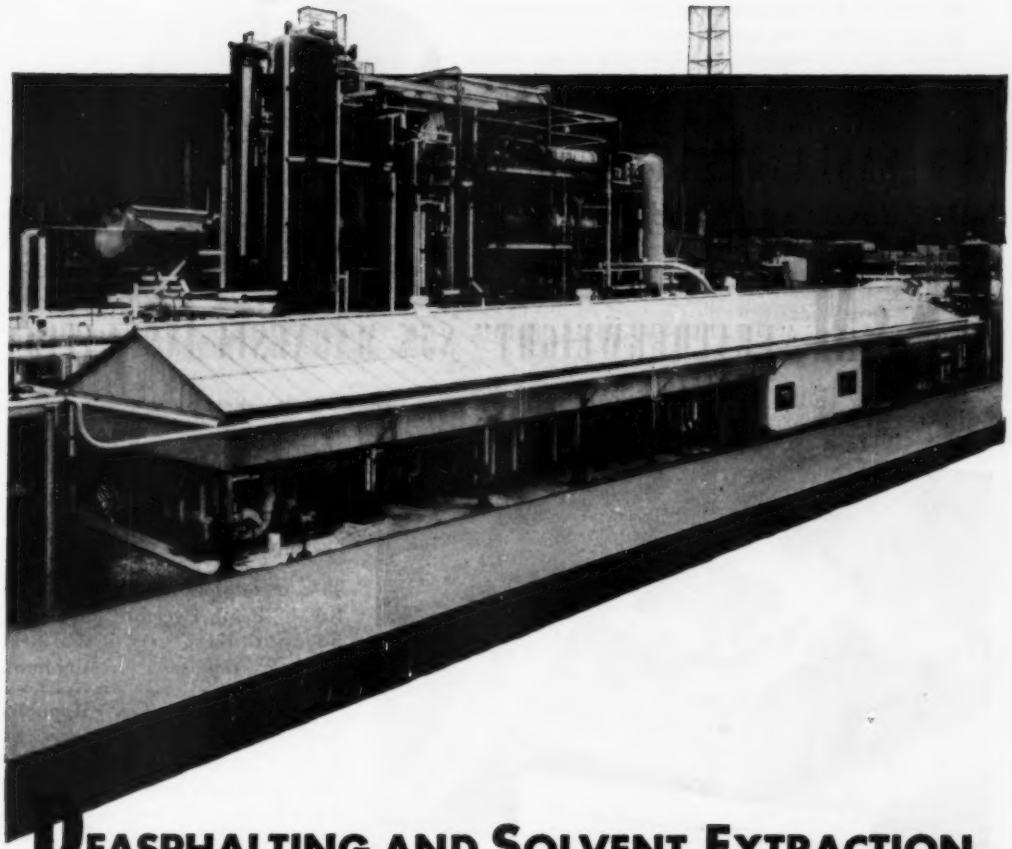
STREET AND NUMBER _____

POST OFFICE _____ ZONE NO. _____ STATE _____

PR-2



PROPANE DEASPHALTING AND PHENOL EXTRACTION UNITS OF THE ATLANTIC REFINING COMPANY AT POINT BREEZE, PENNSYLVANIA



DEASPHALTING AND SOLVENT EXTRACTION

Initial steps in the manufacture of quality lubricants

Propane deasphalting and phenol extraction units were recently completed by Badger for the Atlantic Refining Company.

Processing schedules and economic arrangement dictated the adjacent location of these units with common structures and central control room. Process design included provisions for handling varying stocks with corresponding variations in solvent dosages and operating conditions.

Badger has wide experience in all steps of lube manufacture—vacuum distillation, propane deasphalting, furfural or phenol extraction, M. E. K. dewaxing, clay contacting through to final packaging.

E. B. **BADGER** & SONS CO. Est. 1841

BOSTON 14 • NEW YORK • SAN FRANCISCO • LOS ANGELES • LONDON

A SUBSIDIARY of STONE & WEBSTER, INC.

FOR THE CHEMICAL, PETROLEUM and PETRO-CHEMICAL INDUSTRIES

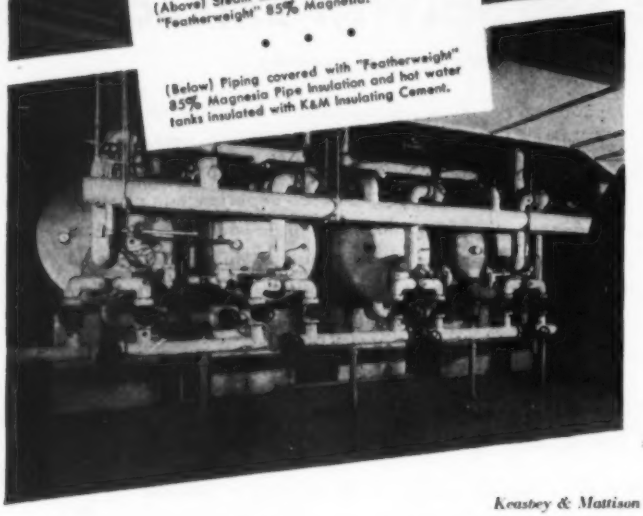
NEW ENGLAND MUTUAL LIFE
holds down overhead costs with

Home Office of New England Mutual Life Insurance Company, Boston, Massachusetts.

K&M "FEATHERWEIGHT" 85% MAGNESIA INSULATION

(Above) Steam lines are insulated with K&M "Featherweight" 85% Magnesia.

• • •



(Below) Piping covered with "Featherweight" 85% Magnesia Pipe Insulation and hot water tanks insulated with K&M Insulating Cement.

This imposing home office of the New England Mutual Life Insurance Company, Boston, is supplied with heat from a central heating plant.

The steam pipes are insulated with K&M "Featherweight" 85% Magnesia with the net result that heat losses are reduced to a minimum.

"Featherweight" 85% Magnesia insulation, first manufactured by K&M 62 years ago, combines the high insulating properties of basic Carbonate of Magnesia with Asbestos Fibre as a binding agent, forming a featherlight, fireproof, efficient insulating material.

K&M Distributors, located strategically throughout the country, are experts on the application of K&M insulation materials . . . and can point the way to savings for you. Write us for further information.

K&M best in asbestos

Nature made Asbestos . . .

Keasbey & Mattison Company has made it serve mankind since 1873.

KEASBEY & MATTISON
COMPANY • AMBLER • PENNSYLVANIA

At your finger tips... Piping for every refinery job

ONE ... SOURCE OF SUPPLY
... RESPONSIBILITY
... STANDARD OF QUALITY

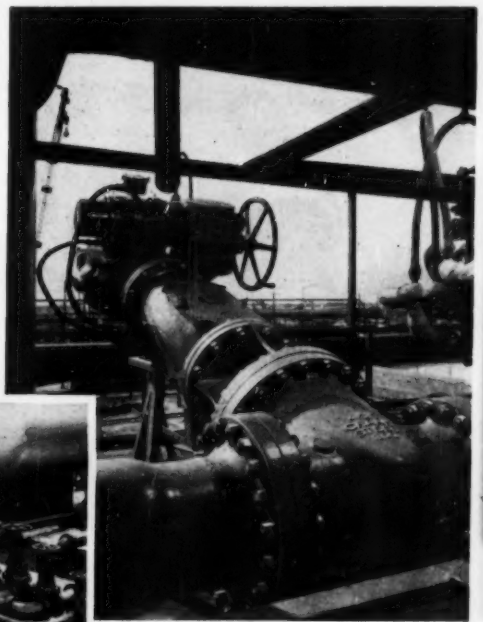
THAT'S what you can expect when you pick up your Crane Catalog. All the valves, fittings, fabricated piping, pipe and accessories you need—all designed to rigid refinery specifications. Whether it's piping equipment for hot oil lines, storage or steam systems, one order to Crane . . . through local Branches and Wholesalers . . . covers everything for the job.

To rely on Crane for all piping is to gain maximum benefit from standardization practices. As the world's most complete **Single Source of Supply,** Crane simplifies every step of piping procedures, from design to erection to maintenance.

Undivided Responsibility for materials—in brass, iron, steel and alloys—helps to assure better installations, avoids needless delays. And in every item from Crane, you get the **Highest Quality** that makes for dependable performance throughout piping systems.

CRANE CO., 836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas

Crane 4 and 6-inch 300-pound cast steel gate valves on lines to pump-out pump in pump room of vapor recovery unit.



Crane 14-inch, 300-pound, motor-operated gate valve on gas line atop compressor house at catalytic cracking unit.

Lines on manifold and mixing coils in continuous sweetening plant equipped with Crane iron body gate valves and flanged fittings.

EVERYTHING FROM . . .

VALVES
FITTINGS
PIPE

CRANE

PLUMBING
AND
HEATING

FOR EVERY PIPING SYSTEM

● WALLS OF UNIFORM THICKNESS
● SMOOTH INNER SURFACES
● PRECISION FORMED TRUE ANGLES — RADII — CIRCULARITY
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● CONTROLLED GRAIN STRUCTURE OF METAL — STRESS RELIEVED
● STRENGTH WITH MINIMUM WEIGHT
all of these advantages · PLUS
... Globe's precision process production from Globe seamless steel tubes to Globe Welding Fittings
All of these advantages are yours in Globe Welding Fittings. Globe's metallurgical experience and highly specialized production and processing facilities are utilized beginning with the production of Globe seamless steel tubes and continuing through every step to the finished Globe welding fittings.
There's plus value in Globe Welding Fittings — send for the catalog.
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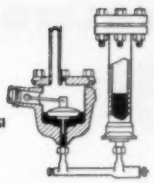
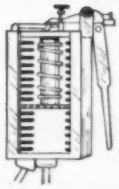
Milwaukee 4, Wisconsin
Producers of Globe seamless stainless steel tubes — Gloweld welded stainless steel tubes — carbon — alloy — seamless steel tubes — Globeiron seamless high purity ingot iron tubes — Globe welding fittings.
GLOBE
PRECISION PROCESS
WELDING FITTINGS



0 TO 10 PSI

30 TO 10,000 PSI



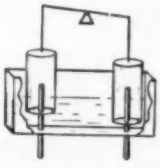
0 TO 30 PSI
(ABSOLUTE)

Here's where to start

14 TO 4,000 PSI

10 TO 17 PSI

5 TO 30 PSI



FURNACE PRESSURE
DRAFT

FOR PRECISE PRESSURE CONTROL

These measuring elements are the heart of Brown pressure control systems for the Petroleum Industry . . . because precision control starts with precise measurement!

Complete coverage of pressure problems necessitates this complete line of elements. There's a specific one for each application . . . from microns to tons . . . from corrosive to non-corrosive! They make Brown Pressure Gauges *the finest available to the Petroleum Industry!*

You'll find detailed information in Catalog 7000 . . . send for it today!

MINNEAPOLIS-HONEYWELL REGULATOR CO.
BROWN INSTRUMENTS DIVISION
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Offices in principal cities of the United States, Canada and throughout the world

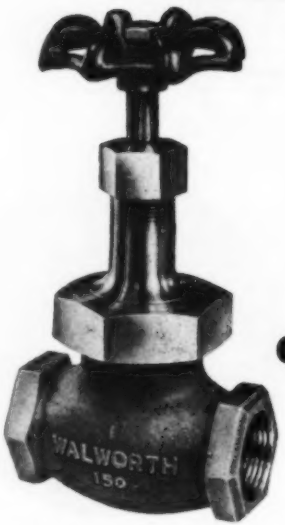
BROWN *Advanced Instrumentation*
FOR THE PETROLEUM INDUSTRY
Product of MINNEAPOLIS **Honeywell**

WALWORTH

Toothed Lock Washer: Prevents loss of stem nut due to vibration, thereby holding the handwheel securely.

Newly Designed Handwheel: Air-cooled, finger grip handwheel affords sure grip even with greasy gloves.

Improved Packing: Molded packing of lubricated asbestos reinforced with copper wire. Suitable for practically every service. Valves can be repacked under pressure.



IMPROVED
No. 95
BRONZE
GLOBE VALVE

also available in Angle Type (No. 96)

The service ratings of the Walworth No. 95 are 150 pounds per square inch steam at 500F, and 300 pounds per square inch non-shock cold water, oil, and gas. In the manufacture of this quality bronze valve, more than 47 gages are used in machining parts to micrometric accuracy, thus insuring interchangeability of parts. For further information see your local Walworth distributor, or write: Walworth Company, 60 East 42nd St., New York 17, N. Y.

note these 7 Great Features

Hexagonal Union Bonnet Connection: Eliminates any chance of distortion or leakage even though valve is repeatedly taken apart and assembled.

WALWORTH
valves and fittings

60 EAST 42nd STREET NEW YORK 17, N. Y.

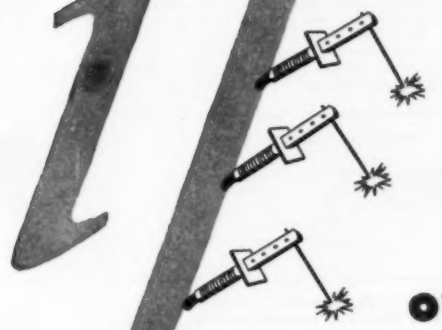
DISTRIBUTORS IN PRINCIPAL CENTERS THROUGHOUT THE WORLD

New Cylindrical Disc Holder: The design of the top portion of the disc holder keeps the disc accurately guided under all operating conditions.

Renewable Asbestos Disc: This disc is suitable for steam up to 500F and is resistant to oil, gasoline, and many chemicals at atmospheric temperatures. Discs for special services are available.

Extra Strong Body: Made of Composition M (ASTM B61) bronze thick enough to provide a high safety factor. Valves undergo hydrostatic shell test of 450 psi.

if



You Weld

MONEL...

MONEL CLAD

or

OVERLAY *with* MONEL

try the new improved

ARCOS MONEND 806

ARC WELDING ELECTRODE

CONSIDER THESE UNUSUAL PROPERTIES

- **X RAY QUALITY WELD METAL**
- **TYPICAL WELD METAL AS WELDED**

Yield Strength	*42,500 psi.*
Tensile Strength	*75,500 psi.*
Elongation in 2"	*42%*
Reduction of Area	*60%*

- **MONEL CLAD (½"—20% CLAD)**
  Typical Free Bend Elongation—53.7%
- **OVERLAY (¾" MILD STEEL BASE)**
  Typical Free Bend Elongation—51.5%

SEND FOR FREE SAMPLES

Address your inquiries to Dept. S.

USE THESE BETTER

Vogt Products

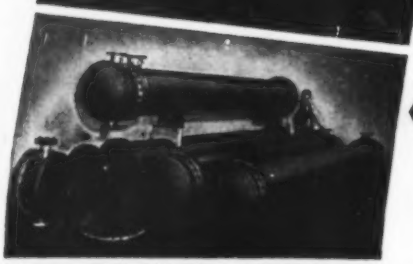
For Today's Tough Service Demands

EFFICIENT AND DEPENDABLE STEAM GENERATION

Vogt steam generating units are designed to give maximum rating in a minimum of space with high efficiency and low maintenance expense. Bent tube types and straight tube, forged steel sectional header types to burn solid, liquid or gaseous fuels, as desired, meet every power, heating or process requirement.

PROCESS EQUIPMENT FOR EVERY SERVICE

Stills, towers, oil chilling machines, filter presses, heat exchangers, etc. are constructed to all Codes. They meet all demands for operating security and trouble-free performance and help to lower costs in important process industries around the world.

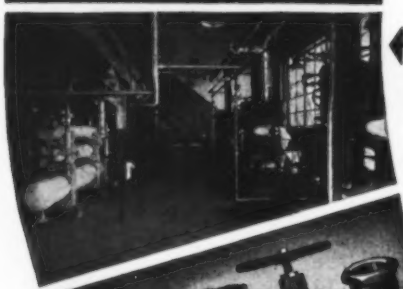


SPECIAL MATERIALS FIGHT CORROSION AND PRODUCT CONTAMINATION

Our modern shops produce a wide variety of equipment made from special metals and alloys to combat corrosion, and product contamination or discoloration. Fabrication procedures employed insure that corrosion resistant properties of welds will match that of the materials from which units are constructed.

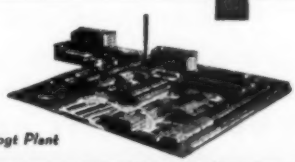
MORE TONNAGE AT LESS COST

Over 60 years of manufacturing experience, engineering and research stand behind Vogt refrigerating and ice making machinery. Absorption Systems, Compression Systems, and the Automatic Tube-Ice Machine in a wide range of capacities serve in leading petroleum refineries, chemical plants, ice and cold storage plants, dairies, packing plants, etc., at home and abroad.



DROP FORGED FOR EXTRA TOUGHNESS AND LONG-TIME SERVICE

Vogt valves, fittings and flanges, for top performance in oil, water, air, gas, and ammonia services, at high or low pressures and temperatures, are available drop forged entirely from carbon steel or stainless steel. Valves can be furnished in a combination of materials by using stainless steel for parts affected by service temperature or corrosion, and less expensive alloys or carbon steel for other parts.



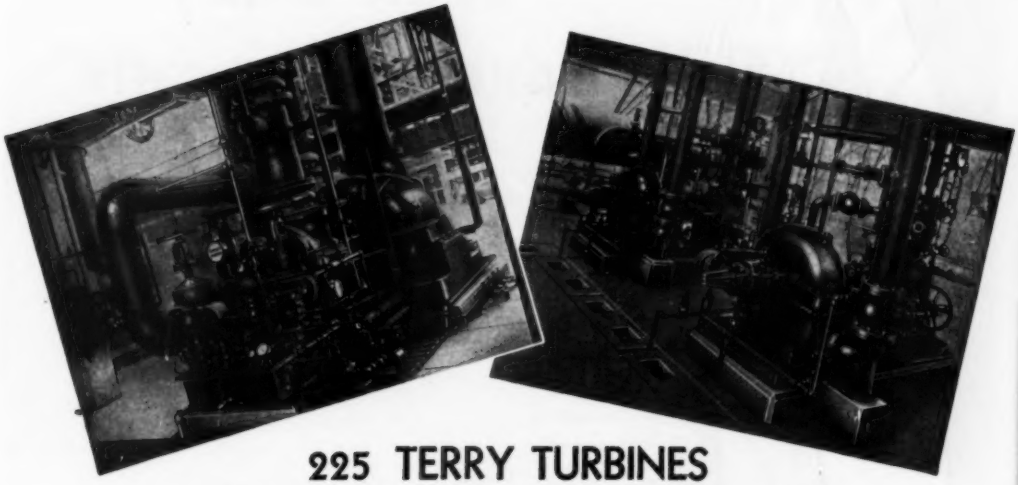
Air View of Vogt Plant

HENRY VOGT MACHINE CO.

LOUISVILLE 10, KENTUCKY

BRANCH OFFICES: NEW YORK, PHILADELPHIA, CLEVELAND, CHICAGO, ST. LOUIS, DALLAS

The TERRY TURBINE



225 TERRY TURBINES
SERVE THE CITIES SERVICE REFINING CORP. AT LAKE CHARLES, LA.

These 225 Specially Designed Terry Turbines are used to drive pumps and compressors at the Cities Service Tutwiler Refinery.

Typical Units are shown above. At the left is an 1800 H. P. condensing multi-staged Turbine direct connected to a blower. At the right are two 175 H. P. Terry solid wheel turbines driving pumps.

The same engineering talent and manufacturing facilities that produced these turbines are available to assist you in obtaining efficient power generation.

Any of our District Representatives will be pleased to give you full information on a turbine drive to meet your requirements. No obligation. May we send you descriptive bulletins?

T-1166

THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD, CONN.

THE price paid for Attapulgus and Porocel adsorbents is around *one cent* per pound—a fact which, we will agree, makes pretty dull reading. But for refiners using our materials, this modest investment pyramids to phenomenal returns. To be specific, each pound properly applied to petroleum stocks increases their value by at least *one dollar*—a return of 100 to 1.

Some three and one-half billion pounds of fullers earth and bauxite have been shipped to refineries by Attapulgus and Porocel—a noteworthy record of service to the industry. But what is even *more* noteworthy is the fact these materials have put three and one-half billion dollars in refinery tills.

That's the record to date. It was accomplished by adsorbent-treating a wide variety of hydrocarbons to effect reduction or removal of colors, odors, tastes, moisture, sulfur, acids, fluorides and unsaturates, and for catalytic purposes. It's a record for *you* to tie to when considering plans to improve quality, expand output, or both.

Consult with us freely. Our broad knowledge of the behavior of our products under many sets of conditions should go far in helping *you* get 100 for 1.

ATTAPULGUS CLAY COMPANY *Fullers Earth* · **POROCEL** CORPORATION *Activated Bauxites*

Dept. W, 210 West Washington Square, Philadelphia 5, Pa.

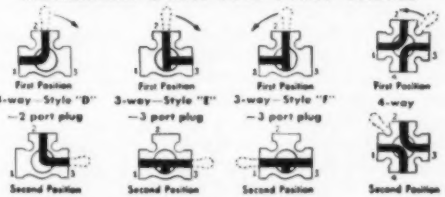
One HOMESTEAD 4-WAY VALVE WILL DO... YOU WILL SAVE THE COST OF *Two*

ONE Homestead 4-Way Quarter-Turn Valve will do the work of three ordinary shut-off valves when used as a fluid "flow changer" or as a "switching" valve. Homestead 4-Way Valves are also ideal for use as operating valves to control single or double acting pistons that travel the full length of their stroke. Their use thus saves initial valve and installation costs, cuts operating time, reduces maintenance expense. Added advantages are the long, trouble-free operation and dependable service typical of all Homestead Valves.

Homestead 3-Way or 4-Way Valves can be furnished in sizes ½" to 12", in brass, acid-resisting bronze, semisteel, steel, monel, Ni-Resist and other alloys for specific temperature, pressure and fluid conditions.

Write today for complete information and copy of Valve Reference Book No. 38.

FLUID FLOW-LINES SHOW HOW YOU CAN USE HOMESTEAD 3-WAY AND 4-WAY VALVES



HOMESTEAD VALVE MFG. CO.

P. O. BOX NO. 16 CORAOPOLIS, PA.

United Gas Line Company, Carthage, Texas. *Ellwood M. Payne* photo.

It'll still be new ten years from now

THIS piping at United Gas Line Company's plant is another sweetly streamlined example of leakproof permanence achieved with *the fittings that become part of the pipe.*

That means Tube-Turn welding fittings. They are preferred for large-scale piping that must remain safe and sound for years with little or no maintenance. Their butt-welded joints simply can't leak. Their forged-in strength equals or exceeds the strength of pipe. Their smooth inner walls and full effective radius minimize friction and erosion.

And yes, they are easy to install. Dimensional accuracy and true circularity make alignment a cinch. The absence of excess bulk permits compact, economical piping assembly.

For good service in good connections, deal with the Tube Turns distributor. He handles the biggest line of welding fittings.

TUBE TURNS, INC.

244 E. Broadway, Dept. D, Louisville 1, Ky.

District Offices at New York, Philadelphia, Pittsburgh, Chicago, Houston, Tulsa, San Francisco, Los Angeles

TUBE-TURN

TRADE MARK

tt

WELDING FITTINGS AND FLANGES

Write for the new and revised Tube Turns' chart of "Pipe and Fitting Materials". Covers ASTM and other specifications, chemistry, service temperature limits, welding data.

reduce maintenance costs

with NATIONAL CONDENSING AND COOLING SECTIONS

SUBSTANTIAL savings in maintenance costs are being realized by many petroleum refineries, chemical plants and by-product coke plants, who are handling their condensing and cooling services with NATIONAL Sections.

Economy in maintenance is inherent in NATIONAL Sections for the following reasons:

- *Simplicity of Design*
- *Ease of Assembly and Replacement*
- *Long Life due to Corrosion Resistance of Cast Iron*
- *Low Spare Part Inventory Requirements*

For information concerning NATIONAL Condensing and Cooling Sections, please write for our Catalog CP-16.

INDUSTRIAL DIVISION

The National Radiator Company

221 CENTRAL AVENUE . . . JOHNSTOWN, PENNSYLVANIA

FOR HANDLING AIR OR GAS—I-R Blowers Have the Preference

EXPERIENCE: The *first* centrifugal gas compressor for a fluid catalytic cracking plant, the *first* turboblower for gas pipeline transmission, the *first* blowers for 40 lb blast furnace blowing . . . they are all Ingersoll-Rand. This is what we mean when we say there is a preference for I-R blowers.

PERFORMANCE: Preference for I-R Blowers is also based on the low Power costs, Low Maintenance Costs and High Availability Factor of every blower we've ever built . . . and we've built thousands of them. If you are buying a blower, investigate power consumption . . . check up on maintenance costs . . . find out if the blower can give continuous performance for long periods . . . these are the only sound reasons for blower selection.

SERVICE: Service that is friendly and competent, backed by full scale engineering and research facilities is another part of the preference for I-R Blowers: Whatever your blower problem, a phone call to an Ingersoll-Rand Branch Office will put you in touch with a thoroughly qualified engineer who will be glad to assist you in any way he can. Take advantage of his experience.

224-12

PAGE WELDING ELECTRODES AND GAS WELDING RODS

WELDING STAINLESS?

○

TO RESIST WHAT?

HEAT?
COLD?
IMPACT?
BENDING FATIGUE?
CORROSION?
WHAT KIND OF CORROSION?

○

NOW ONE MORE QUESTION:

Are you using the best electrode or rod for your purpose?

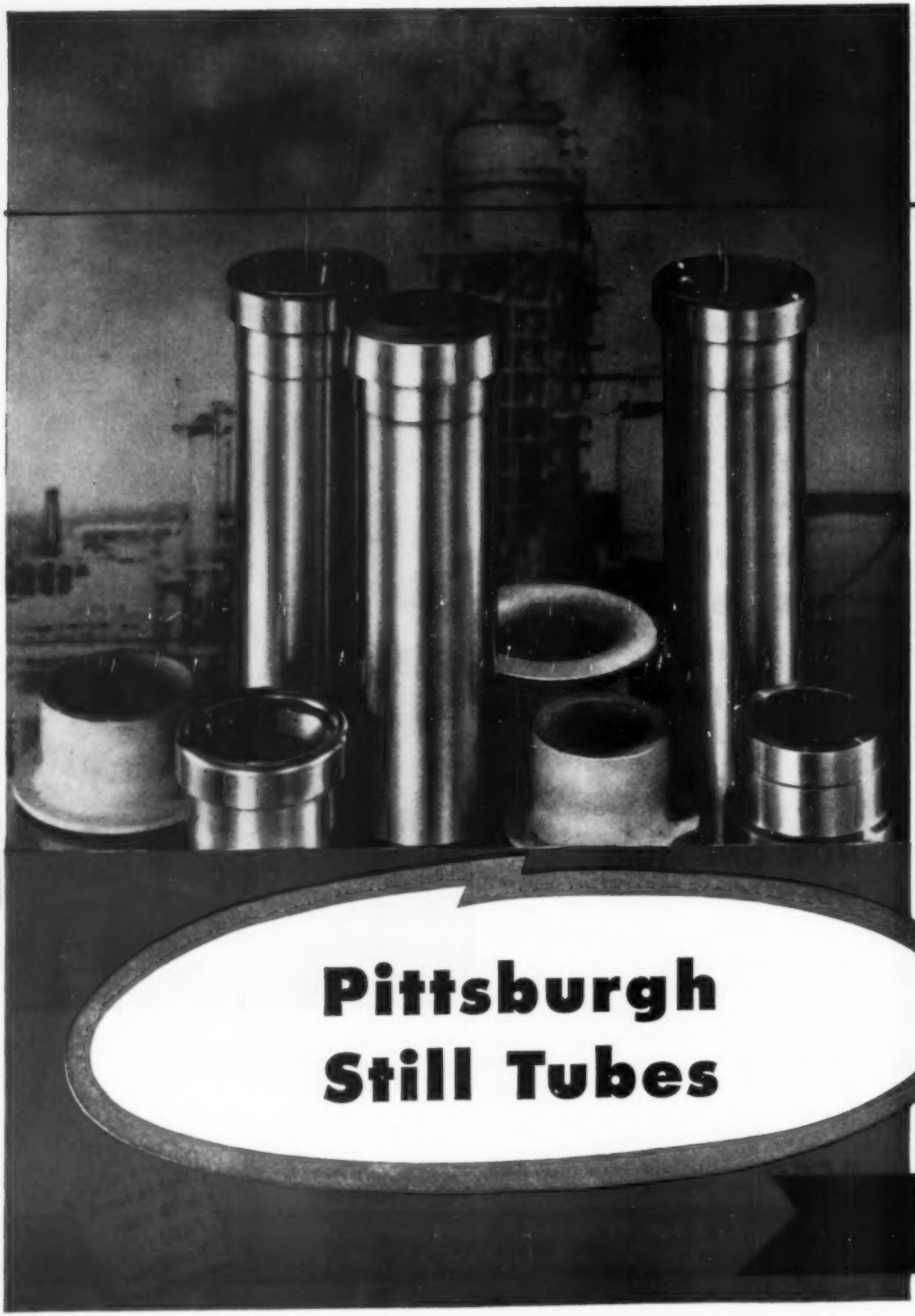
If you're not too sure, get in touch with your PAGE distributor. Either he knows or he can find out from the PAGE Field Service Man. And the PAGE distributor has a wide selection of Page-Allegheny Stainless Steel rods and electrodes, so that he can give you the one that will serve you best.

ACCO

Monessen, Pa., Atlanta, Chicago, Denver, Detroit, Los Angeles, New York, Philadelphia, Pittsburgh, Portland, San Francisco, Bridgeport, Conn.

PAGE STEEL AND WIRE DIVISION
AMERICAN CHAIN & CABLE

Get in touch with your PAGE Distributor


Pittsburgh
Still Tubes

Uniform Performance

You get uniform resistance to heat, pressure, oxidation and corrosion with Pittsburgh Still Tubes. Each tube is produced by a combination of skilled men and modern equipment working as a unit to make high quality carbon and alloy tubes consistantly.

Pittsburgh Still Tubes are made in a full range of carbon and alloy steels—2″ to 6″ outside diameter (in some cases even larger) from .134″ to 1″ average of minimum wall thickness in lengths up to 55′ with plain or upset and machined ends. To get economical still tube performance write Pittsburgh Steel Company, Pittsburgh 30, Pa.

Pittsburgh Steel Company

YOU USE 4 + 8 YOU GET 100,000

That's all it takes! Four basic circuits and 8 basic component parts give you more than 100,000 different electronic instrument combinations for processing use.

Flow, level, speed, pressure, temperature, gas analysis, pH, conductivity, etc.—all can be controlled with these interchangeable Bailey units.

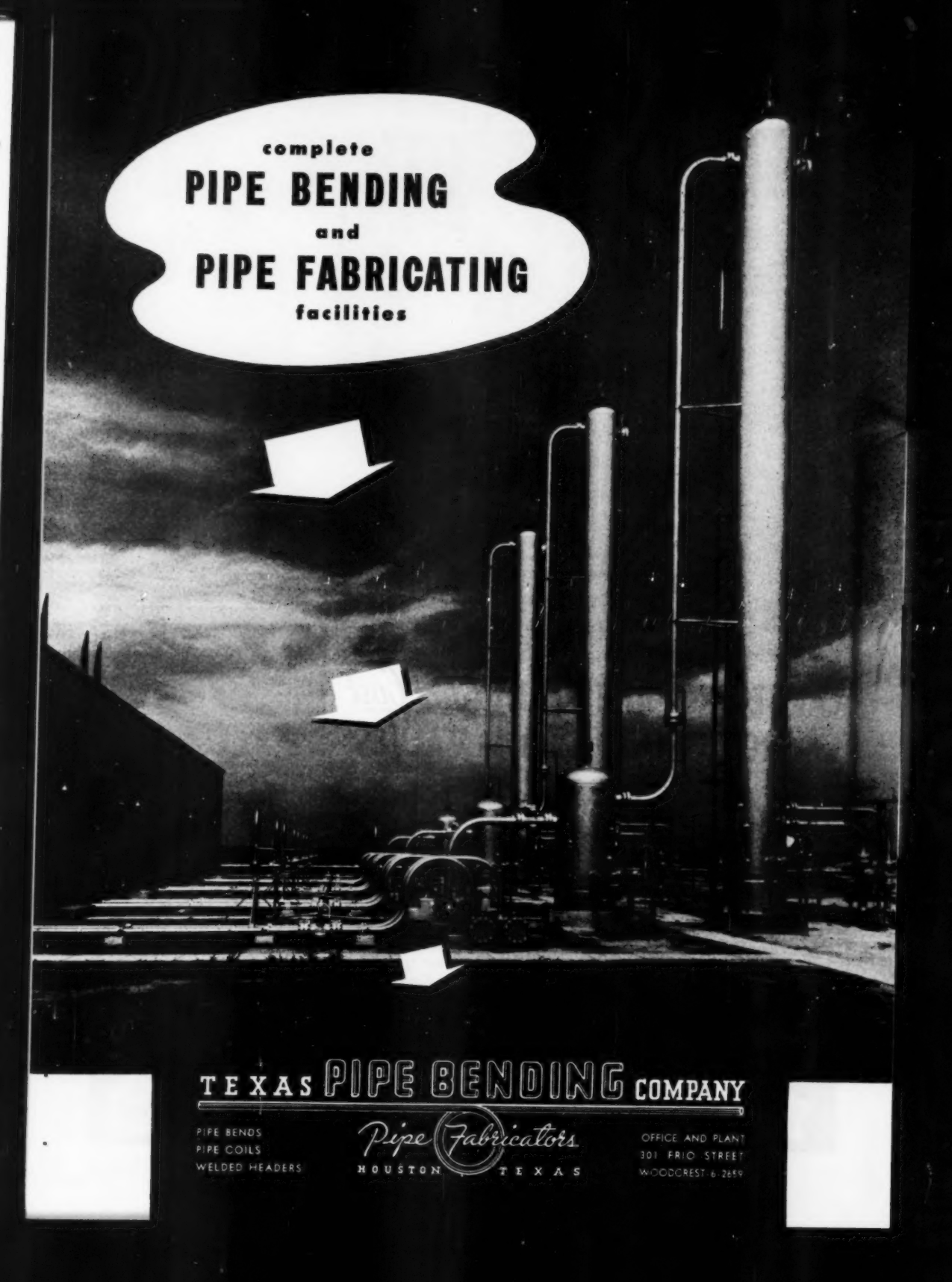
With Bailey controls, replacement part stocks are held to a minimum because parts are interchangeable. Maintenance costs are less, too, because maintenance men quickly become familiar with the standardized Bailey units.

Bailey bulletin No. 17 shows how you can use this improved control system. Write for your copy and keep it handy for reference the next time you need process controls:

P-19-O

BAILEY METER CO.
1043 Ivanhoe Rd. • Cleveland 10, Ohio
BAILEY METER CO. LIMITED, MONTREAL
Controls for the Oil Industry
TEMPERATURE • FLOW • PRESSURE
GAS ANALYSIS • LEVEL • RATIO

4 + 8 Works Here at Wood River Refinery of Shell Oil Company


complete
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facilities
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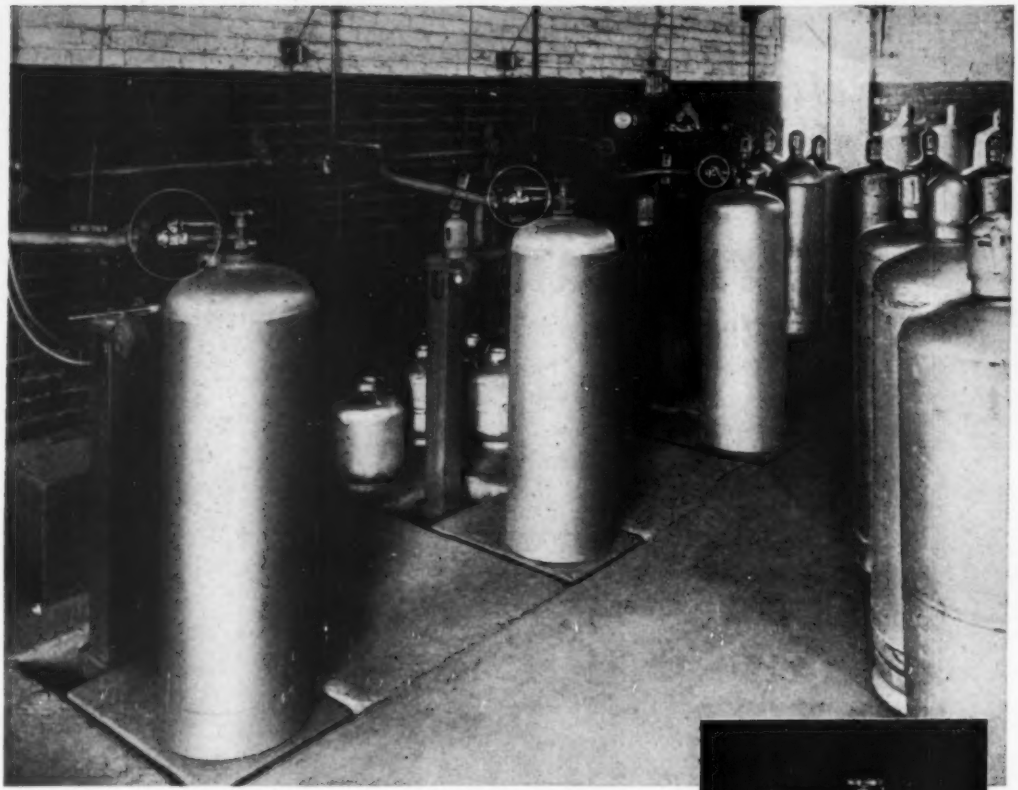
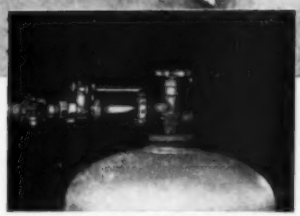


LARGE PROPANE PLANT *Cuts Cost* with ROCKWOOD Ball Type VALVES



½" Rockwood Ball Type Valve attached to tank helps speed the handling of "**bottled gas**". Note the construction and design of the valve —operator filling tanks can quickly open or close valve under full pressure with an easy quarter turn movement.

The demand for liquefied petroleum gas has reached record highs in this large propane plant. Rockwood Ball Type Valves have increased the production of "bottled gas" by *cutting down* time and labor of operators. Each valve is opened and closed every two minutes during the day and between 300 and 400 tanks are shipped out daily to suburban and rural householders.

Plant supervisor is highly pleased with performance and action of the Rockwood Ball Type Valves. He says there is no question that the full *round* flow, tight seal and quick opening and closing features of the valves have contributed to greater production at lower cost.

Available in bronze with screwed ends in all pipe sizes from ½" to 2" for 175 p.s.i. working pressure, the Rockwood Ball Type Valve is recommended for handling water, oil, gas, petroleums, food lines, carbon dioxide, nitrogen and other gases, paraffin and asphalt base petroleums, also alcohol, paper fluids, and many other types of liquids and gases.

For additional uses and information on the Rockwood Ball Type Valve, write today for bulletin V-4.

Distributors in all principal cities.

ROCKWOOD SPRINKLER CO

102 HARLOW STREET WORCESTER 5, MASS

AN "EYE-OPENER" IN

Interchangeability

OF PARTS

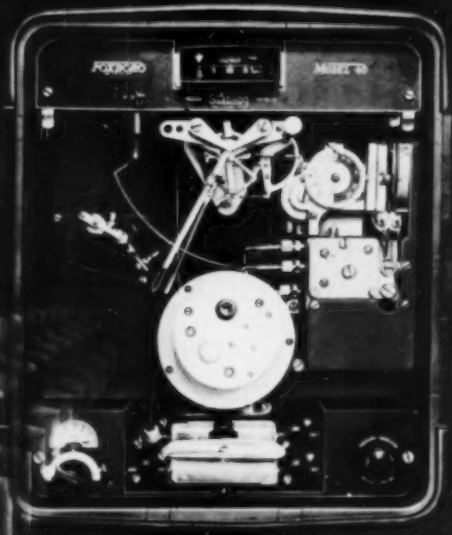
THE EASY, trouble-free interchangeability of M-40 parts makes instrument men sit up and take notice. For this is an ace in the hole to them in case of emergency. It means the end of time-wasting, costly delays in fitting and adjusting replacements of parts accidentally damaged.

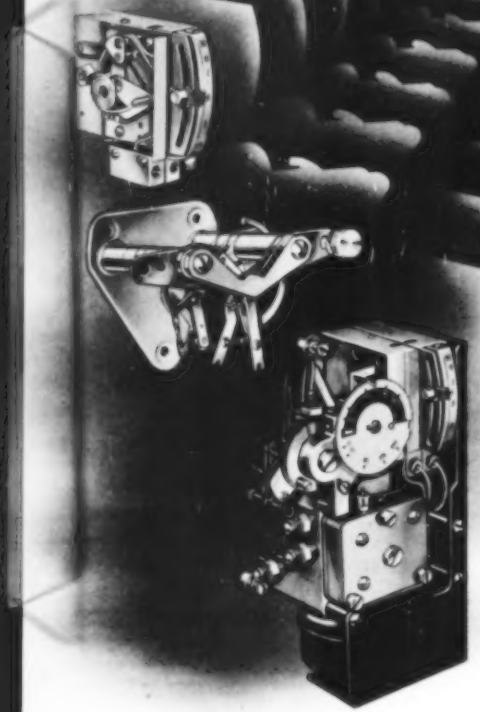
This interchangeability of parts is no happenstance. Every part was designed to eliminate variations that might necessitate critical field adjustments . . . and vital parts were built to machine tool precision. In the eyes of expert instrument men, interchangeability is another important advantage that makes M-40 the outstanding modern controller.

FOXBORO REG. U. S. PAT. OFF. *M-40*

"THE FINEST MODERN CONTROLLER"

The Model 40 Pneumatic Controller is available for temperature, pressure, flow, liquid level, humidity, density, etc., in a full range of control actions and combinations. Write for Bulletin 381. **The Foxboro Company, 262 Neponset Avenue, Foxboro, Mass., U. S. A.**





Identical Performers

construction makes duplication of parts easy

All main and sub-assemblies of the Model 40 Controller may be interchanged freely without impairing the accuracy and stability of the instrument. If, for example, the control relay should ever need replacing, another may be easily substituted with positive assurance that it will restore the original performance characteristics.

A closer examination of the control relay shows that its design and construction are so basic, so free from complicated parts and critical adjustments, that there are no manufacturing problems in turning out duplicate performers. It also shows that proper alignment of control relay with other parts is automatically assured.

This advanced engineering, typical of M-40 design and construction, is another important reason why M-40 is the finest modern controller.

FOXBORO
REG. U. S. PAT. OFF.

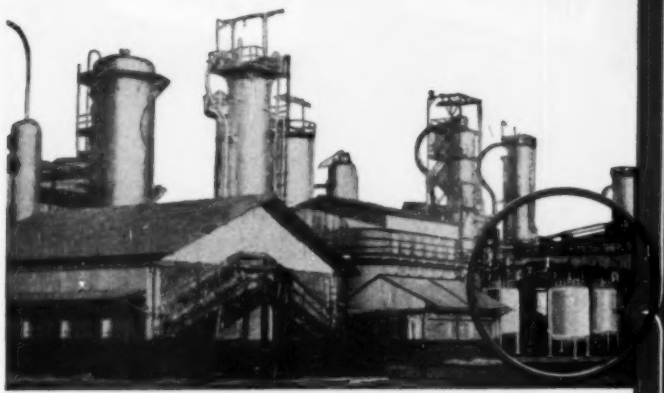
M-40

"THE FINEST MODERN CONTROLLER"

FOR PRECISION PROCESSING THE SUREST STEP IS

NOOTER
ST. LOUIS

PRECISION FABRICATION



Flawless construction that insures flawless performance through "Plus Factors"

Middle gauge or heavy plate welded construction — carbon, alloy or clad steels — Fractionating towers and pressure vessels — Stress relieving and hydrostatic testing. Nooter welding techniques embody every phase of API-ASME code procedures.

"PLUS FACTORS?" you might ask. Those are the things that count so much in Nooter fabrication . . . *not* called for in your blue prints or specifications. These plus factors are Nooter's 54 years of specialized experience combined with extensive facilities. They are the important reasons why every type of pressure or heat transfer equipment is entrusted to Nooter — from the blue print to the fit-up.

To be sure of performance, be sure of *fabrication* — get in touch with Nooter.

Send for Nooter Catalog with Corrosion Data Tables.

JOHN NOOTER BOILER WORKS CO. • 1404 South Second St. • St. Louis 4, Mo.

NUMBER 2 OF A SERIES

Pacific's Proved Performance

helps make Record Runs

AT THE CITIES SERVICE LAKE CHARLES, LOUISIANA, REFINERY

Photo Courtesy M. W. Kellogg Co.

Fluid "Cats" A, B and C at the Cities Service Lake Charles Louisiana Refinery are served by Pacific Centrifugal Pumps. The record runs made by each unit prove Pacific Pumps "can take it" whether the service demands 10,296, 12,960 or 13,488 hours of continuous service pumping hot or cold oils, slurries, or water.

FOR CONTINUOUS
DEPENDABLE –
ECONOMICAL SERVICE
SPECIFY: PACIFIC
CENTRIFUGAL PUMPS.

PR-5

PACIFIC
Precision Built
PUMPS

PACIFIC PUMPS INC.
HUNTINGTON PARK, CALIFORNIA
One of the Dresser Industries
Export Office: Chanin Building, 122 East 42nd Street, New York
Offices in All Principal Cities

the New

DE LAVAL VELOCITY-STAGE TURBINE

A *Improved bucket and nozzle ring design,* for high efficiency.

B *Center line support and flexible mountings,* to avoid misalignment from thermal expansion.

C *Steam chest in lower half of casing,* to permit removal of casing cover without disturbing piping.

D *Improved speed control.* Balanced regulating valve and direct acting governor permit close speed regulation. Speed can be varied readily while turbine is running.

E *Separate trip mechanism* and emergency closing valve, operated by speed governor independent of speed regulating valve.

And many other improved features.

DE LAVAL
STEAM TURBINE CO.
TRENTON 2, NEW JERSEY

Atlanta • Philadelphia • Los Angeles • Chicago • Pittsburgh
San Francisco • St. Paul • Cleveland • Tulsa • Boston • Charlotte
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T-14

TURBINES • HELICAL GEARS • WORM GEAR SPEED REDUCERS • CENTRIFUGAL PUMPS • CENTRIFUGAL BLOWERS AND COMPRESSORS • IMO OIL PUMPS

FOR YOUR HEAT EXCHANGERS OR CONDENSERS, THIS W&T CHLORINATOR CAN:

- Reduce down time
- Cut operating costs
- Improve heat transfer

The machine shown is a W&T Visible Vacuum Chlorinator for the application of chlorine to cooling water circuits through the W&T De-sliming process. Its design is the result of over thirty-five years of pioneering in chlorination, plus the accumulated experience of thousands of installations throughout the world.

Because of the care put into its design and construction, this chlorinator can do these things economically and dependably:

REDUCE DOWN TIME and eliminate costly plug cleaning by ridding condenser tubes of bacterial-induced slime growths.

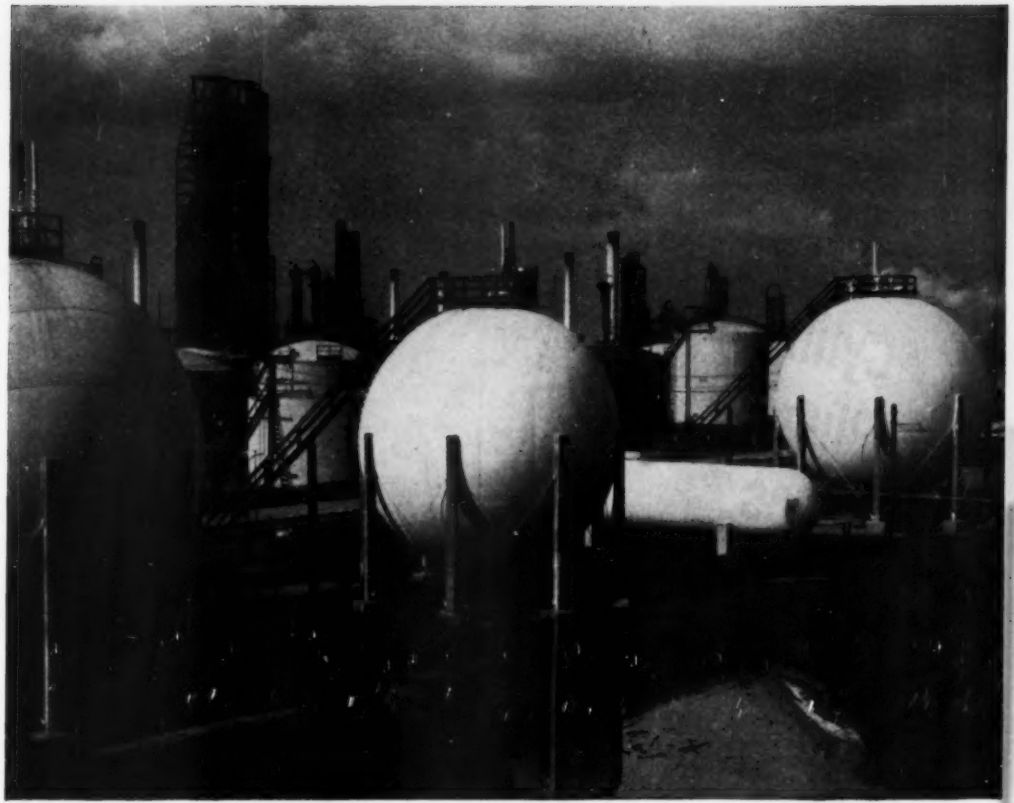
CUT OPERATING COSTS by keeping condensers and other heat exchange equipment in service longer without shut-down and, at the same time, give higher operating efficiencies.

IMPROVE HEAT TRANSFER by keeping water-side surfaces continuously protected against the formation of a slime layer.

For complete information on how these advantages can go to work for you, write today. There's no obligation.

WALLACE & TIERNAN
PRODUCTS, INC.
CHLORINE AND CHEMICAL CONTROL EQUIPMENT
Belleville 9, New Jersey • Represented in Principal Cities

CD-30



WHERE PRESSURE PLAYS A PART

Where petroleum products must be stored under the higher pressures, Graver spheres or bullet-shaped vessels are proving their value to refineries, marketing facilities and processing plants everywhere.

Available in a full range of capacities and working pressures, Graver pressure vessels are built in strict compliance with all codes which apply and according to the latest techniques for the manufacture of either shop built or field erected tanks. Where stress-relieving, x-raying or radiographing is necessary, Graver maintains the latest in modern facilities to efficiently handle each specific requirement.

It's this close attention to details together with the most complete manufacturing facilities... backed by over three-quarters of a century of experience in steel plate fabricating... that makes Graver pressure vessels dependable.

Why not specify Graver the next time you plan petroleum storage facilities where pressure plays a part?

FABRICATED PLATE DIVISION

GRAVER TANK & MFG. CO., INC.

East Chicago, Indiana

Graver offers a complete service to the petroleum industry including Expansion Roof Tanks, Floating Roof Tanks and pressure vessels. In addition, Graver is prepared to furnish specialized steel plate work such as fractionating columns and class one vessels as well as stainless and alloy fabrication; water conditioning equipment of all types; and through the Graver Construction Co., is prepared to handle all types of petroleum and chemical construction work.

GRAVER

NEW YORK • PHILADELPHIA • CHICAGO • CATASAUQUA, PA. • HOUSTON • SAND SPRINGS, OKLA.

Cylindrical
Plug
gives
full pipe area
The result is smooth, non-turbulent flow...lowest head loss... reduced valve abrasion. Yet compact plug valve construction is retained.

CYLINDRICAL

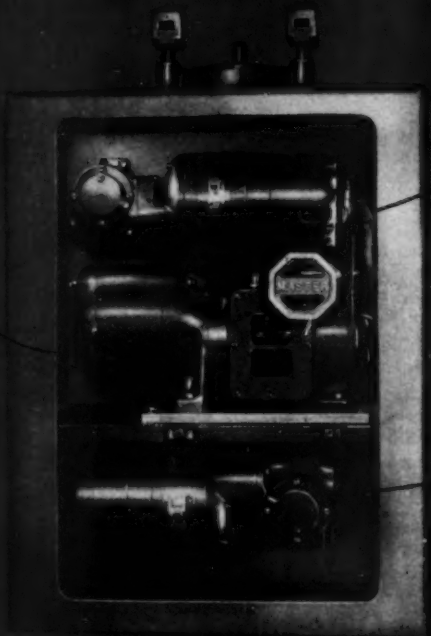
a.c.f. FULL PIPE AREA PLUG VALVES

LUBRICATED

Representatives in more than 50 principal cities.

A.C.F. Plug Valves are ideal where the lading is viscous or contains suspended solids. Write for catalog No. OG-9 direct to American Car and Foundry Company, Valve Division, 30 Church Street, New York 8, N. Y.

Easy does it



Don't put up with make-shift assemblies when it is so easy to get the RIGHT horsepower, the RIGHT shaft speed, the RIGHT construction features, the RIGHT mounting . . . all combined into one compact power package.

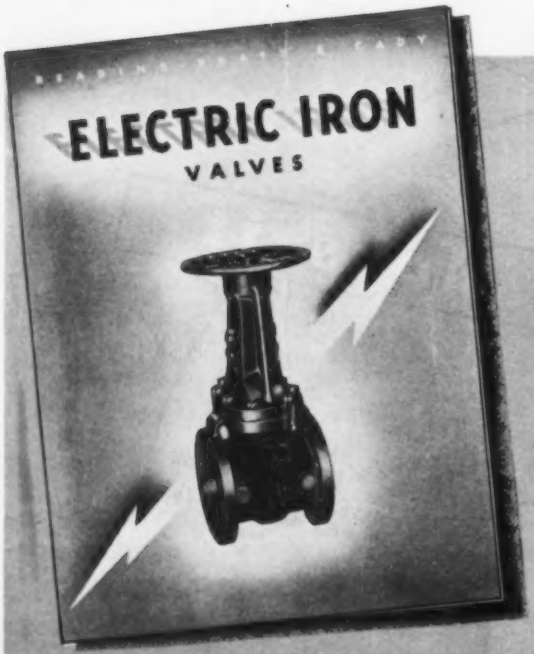
Master Motors, available in millions on millions of combinations of types and ratings, permit you to use a power drive on each job that's just right . . . a power drive that will add greatly to the compactness, appearance, and economy of each of your applications.

Use Master Motors to increase the salability of your motor-driven products . . . improve the economy and productivity of your plant equipment. They're the horsesense way to use horsepower.

THE MASTER ELECTRIC COMPANY
DAYTON 1, OHIO

BETTER IRON MAKES BETTER VALVES AT READING-PRATT & CADY

There is one *BEST* method of melting and refining iron for valve castings. It is R-P&C's *Electric Furnace method.*

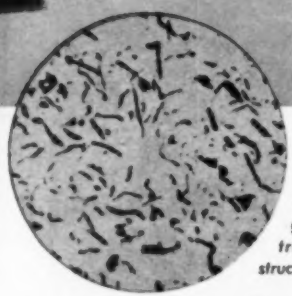


YOU PAY NO PREMIUM for the extra quality in R-P&C Electric Iron Valves. But you do get better valves — longer lasting, more dependable.

Electric Furnace Cast Iron is a low-sulphur, low-phosphorus iron of homogeneous, fine-grained structure. It is clean and of uniform quality.

Before buying or specifying iron valves, get the complete story of R-P&C Electric Furnace Iron. Write for our descriptive folder—DH-18.

THIS FOLDER tells you why Electric Iron is better than iron made by the conventional cupola process. Interesting information if you buy or specify iron valves. Write for DH-18.



UNIFORM STRUCTURE

Photomicrograph (enlarged 100 times) shows even distribution of fine graphite flakes. This contributes to the uniform structure of R-P&C Electric Iron.

ACCO

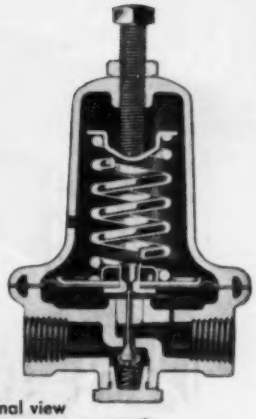
Reading, Pa. • Atlanta • Baltimore • Boston • Chicago • Denver • Detroit • Houston
New York • Philadelphia • Pittsburgh • San Francisco • Bridgeport, Conn.

READING-PRATT & CADY DIVISION
AMERICAN CHAIN & CABLE

TRADE MARK

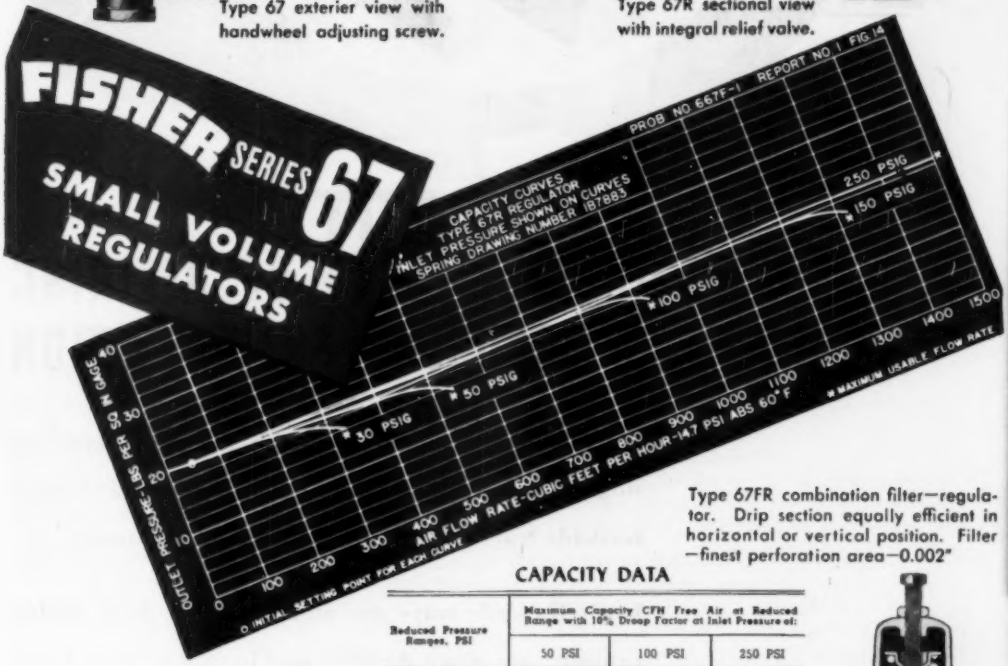
The Fisher Series 67 Regulator for small volume air or gas flows is designed to furnish industry with an improved economical regulator with the ability to do an outstanding job of **accurate, efficient regulation.** It will not vibrate, chatter or sing and has capacity up to 6 C.F.M.

Fisher Series 67 Regulators are ideal for hundreds of miscellaneous industrial uses—they are particularly adapted to instrument air service, supplying 20 lbs. operating medium pressure to instruments and pilot operated regulators.



Type 67 exterier view with handwheel adjusting screw.

Type 67R sectional view with integral relief valve.

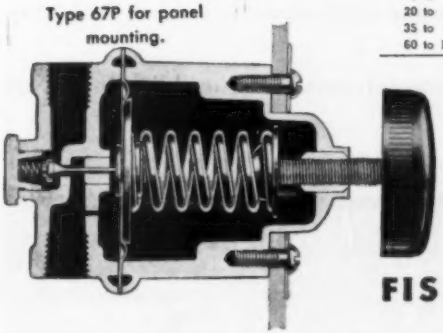

FISHER SERIES 67
SMALL VOLUME REGULATORS
CAPACITY CURVES
TYPE 67R REGULATOR
INLET PRESSURE SHOWN ON CURVES
SPRING DRAWING NUMBER 187883
PROB NO 6677-1 REPORT NO 1 FIG 14
250 PSIG
150 PSIG
100 PSIG
50 PSIG
30 PSIG
OUTLET PRESSURE-LBS PER SQ IN GAGE
AIR FLOW RATE-CUBIC FEET PER HOUR-14.7 PSI ABS 60° F
MAXIMUM USABLE FLOW RATE
INITIAL SETTING POINT FOR EACH CURVE

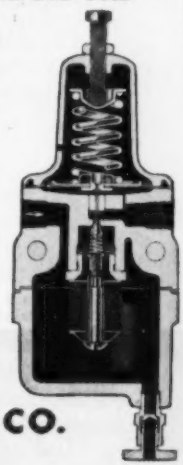
Type 67FR combination filter—regulator. Drip section equally efficient in horizontal or vertical position. Filter—finest perforation area—0.002"

CAPACITY DATA

Reduced Pressure Ranges, PSI	Maximum Capacity CFH Free Air at Reduced Range with 10% Droop Factor at Inlet Pressure of:		
	50 PSI	100 PSI	250 PSI
5 to 20	350	750	1400
20 to 35	400	750	1400
35 to 60	125	450	1400
60 to 100		350	900

Type 67P for panel mounting.





SPECIFICATIONS:

Size—¼".

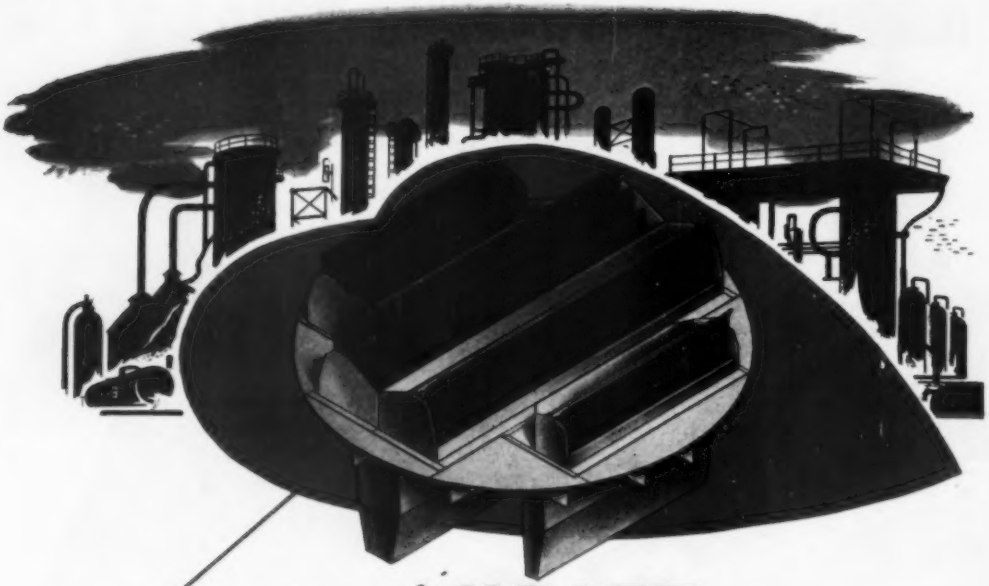
Maximum inlet pressure—250 PSI.

Body—Aluminum, alodine finish and painted.

Dimension—Over all height 5 5-16"—(67FR 9 3-8") face to face 2 7-8".

For further details and complete specifications write for Fisher Bulletin 67.

FISHER GOVERNOR CO.
MARSHALLTOWN, IOWA



THE *HEART OF REFINING IS EFFICIENT FRACTIONATION

Fractionating towers are probably the most important single item of equipment to the refiner . . . and Koch Kaskade trays will double the value of any tower.

Koch Kaskade trays are more efficient, have higher capacity, are more flexible, and in every way a better piece of fractionating equipment than any bubble tray.

Write for complete information. No obligation at all.

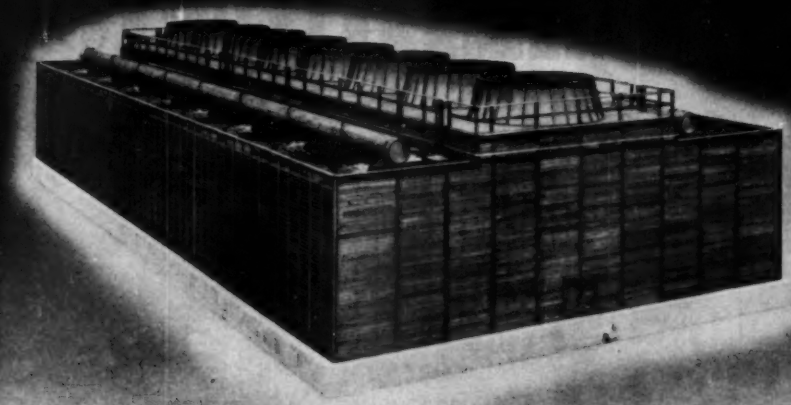
WE'LL BE GLAD TO SEND YOU BULLETIN R-101

Sales Representative
George P. Gregory
30 Rockefeller Plaza
New York City

THE KOCH ENGINEERING COMPANY, INC.
Designers • Manufacturers • Builders
335 West Lewis Street
WICHITA 2, KANSAS

British Associates
Messrs. A. F. Craig
& Company, Ltd.
Paisley, Scotland

Specify MARLEY Double-Flow



WITH THE OPEN DISTRIBUTION SYSTEM

Marley Double-Flow Cooling Towers have an Open Distribution System.

And why is that important?

Because the Marley Open Distribution System is . . .

EASY TO INSPECT . . . it's on top of the tower, in broad daylight, never hidden from view.

EASY TO REGULATE . . . a widely varying GPM may be circulated over the tower without revamping the distribution system.

EASY TO CLEAN . . . cleaning is done with an ordinary broom . . . it is not necessary to shut down the tower or take it apart in any way.

UNUSUALLY SAFE . . . no climbing through small portholes, across slippery members . . . no danger of falling through the filling while crawling about in narrow spaces in semi-darkness while inspecting or cleaning.

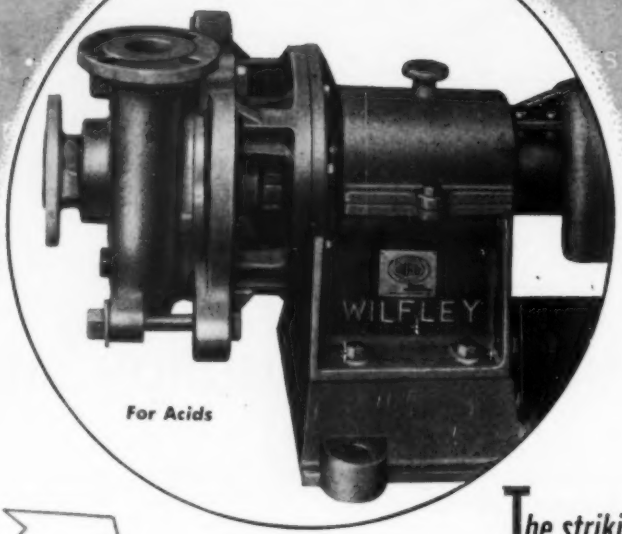
VERY ECONOMICAL . . . because it's easy to clean . . . and clean distribution systems insure top performance and low operating costs. Also, the diffusion decking underneath gives excellent water break-up with no added pumping head.

Ask for a MARLEY Factory-Trained APPLICATION ENGINEER to tell you more about the MARLEY DOUBLE-FLOW Cooling Tower with the OPEN DISTRIBUTION SYSTEM. He'll be glad to help you solve YOUR water cooling problems. No cost or obligation.

MARLEY COOLING TOWERS

THE MARLEY COMPANY, INC. • KANSAS CITY 15, KANSAS

A BIG FACTOR IN COST REDUCTION



For Acids

A Companion to the Famous WILFLEY Sand Pump

•

Buy WILFLEY for Cost Saving Performance

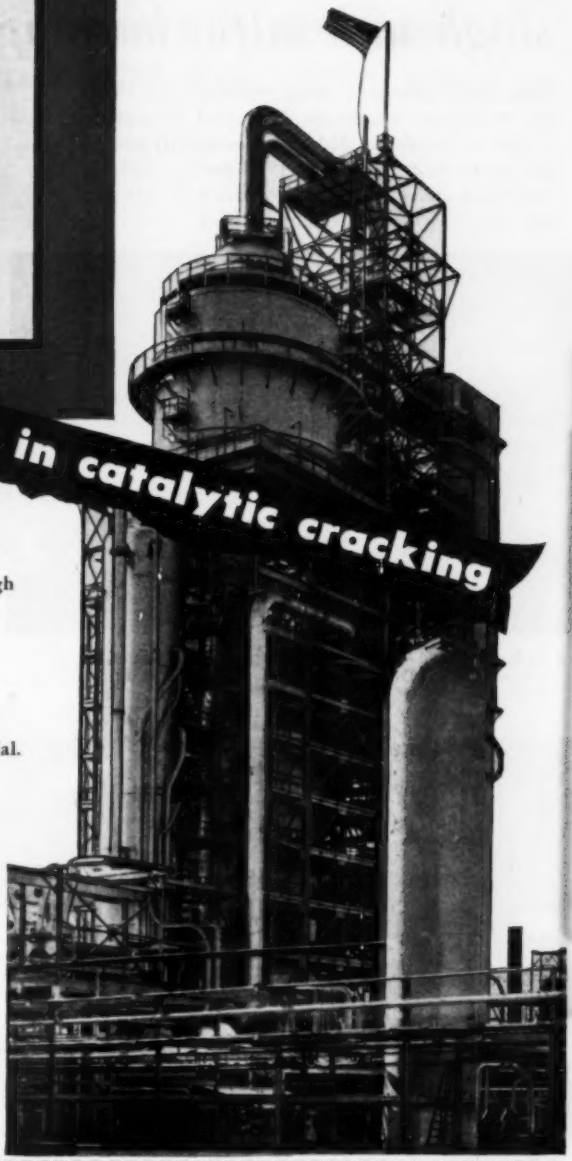
The striking efficiency of the WILFLEY Acid Pump—measured in terms of power saving and continuous, trouble-free handling of acids, corrosives, hot liquids and mild abrasives—is a big cost-reducing factor in most of the modern chemical plants of America. This is the acid pump that delivers full production on a 24-hour basis without attention. 10- to 2,000-G.P.M. capacities; 15- to 150-ft. heads and higher. Individual engineering on every application. Write or wire for information that will help reduce YOUR costs.

A. R. WILFLEY & SONS, INC., DENVER, COLORADO, U. S. A.
New York Office: 1775 Broadway, New York City

WILFLEY *Acid* PUMPS

DA-1

big operator in catalytic cracking



DA-1*—Davison (Synthetic Silica Alumina) Fluid Cracking Catalyst — contributes yearly to the production of enough gasoline to drive every one of America's 34,000,000 passenger cars 800 miles.

Close laboratory control over the production of DA-1 assures its users of a consistently uniform high standard material.

To meet the varied requirements of the refinery operators, DA-1 is available in three grades:

F-1, Fine Grind

C-1, Intermediate Grind

C-2, Coarse Grind

Write for information and specifications.

*®

THE DAVISON CHEMICAL CORPORATION

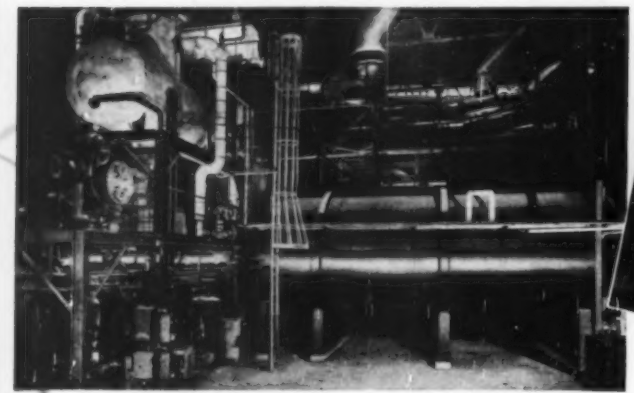
Progress through Chemistry

BALTIMORE-3, MD.

World's Largest

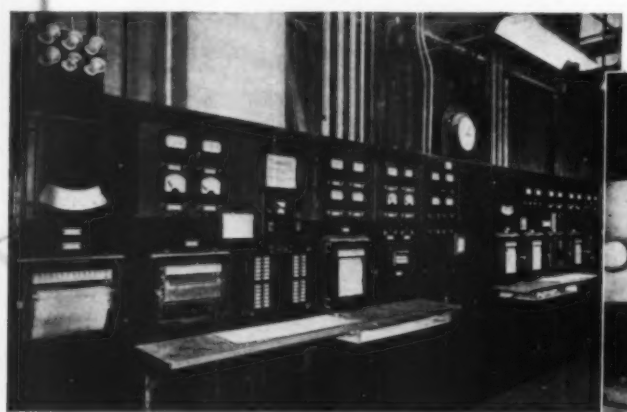
single unit sulfur burning contact acid plant

This sixth Chemico Contact Sulfuric Acid Plant for Standard Wholesale Acid and Phosphate Works in Baltimore, Md. was successfully placed in operation in December, 1948 and is regularly operating above guaranteed capacity of 500 tons per day. (100% equivalent H_2SO_4).



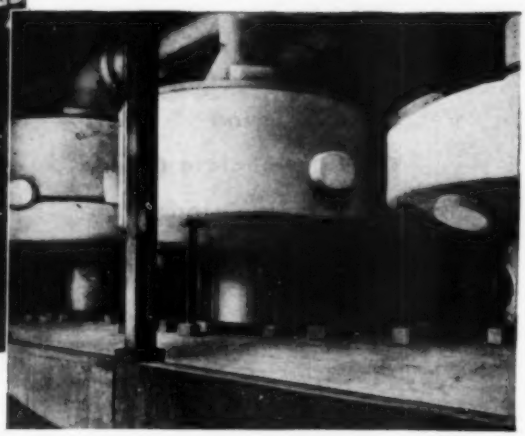
▲ At the right is the Sulfur Furnace with the waste heat boiler, condenser and auxiliary apparatus at the left. This furnace burns over 170 tons of sulfur a day.

▲ Towers for the production of oleum, 98% acid and for the drying of combustion air. These are part of the drying and absorption system.



▲ Here are control panels for two of the six Chemico Contact Acid Plants. The new 500-ton plant panel is on the right.

▼ Shown left to right are the secondary converter, the primary converter and the gas filter.



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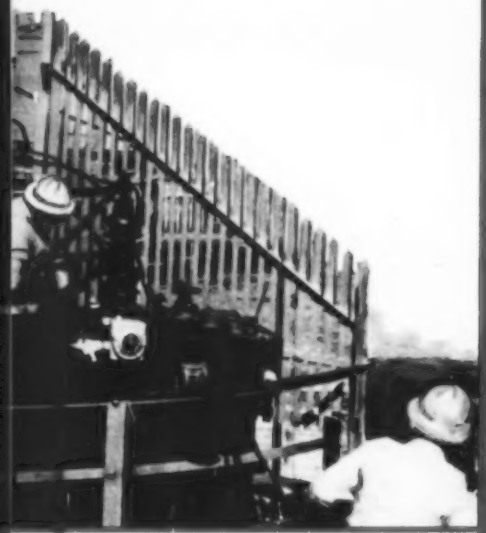

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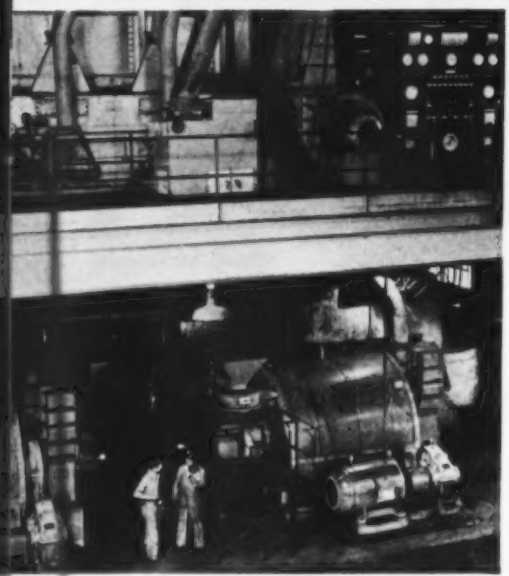

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PETROLEUM
REFINER

VOLUME 28, NO. 2 FEBRUARY, 1949

The LOOK BOX

THE format presently used by PETROLEUM REFINER was decided upon some years back after careful weighing of the many factors involved. From time to time this decision has been subjected to critical review, to the end that the best interests of our readers and advertisers be most fully accommodated.

Slightly Changed Refiner Format

A principal consideration in this problem of format selection in recent years has been the desire of many readers to clip and file specific articles for reference purposes. Since the main editorial content is grouped to run continuously in the "center of the book," there have been frequent cases where the first page of one article has been printed on the same sheet of paper with the last page of the preceding article. This, of course, makes separation of the two articles impossible, and imposes on the "clipper" the choice of discarding one article, using an involved cross-index file system, obtaining a photostat, or obtaining two copies of PETROLEUM REFINER.

None of these solutions is particularly desirable. An alternate is to be found in some kind of format change that mixes advertising and editorial, so that articles can be separated by ads. Here, however, are involved the interests of those many readers who each year bind the entire editorial contents into a single volume. Nearly all of them greatly prefer the present arrangement.

As a result of considerable checking and study, we have concluded that the best solution at present is to revise the format along quite conservative lines, to the end that articles can be separated for filing. It is hoped that this improvement can be effected by comparatively minor rearrangement of editorial material, without other changes in format. If this proves feasible, we will do it. If not, we may eventually have to adopt the mixed advertising-editorial matter technique, always avoiding the jumping of an article over several pages.

In this present issue we have effected the much desired "separability" of those articles which are considered likely notebook and file cabinet material, principally by means of special arrangement. If future issues can be worked out as well the solution will probably prove satisfactory to all.

ALTHOUGH approximately one billion British thermal units of energy are consumed in this country each second, day and night, less than one-third are used productively, according to William M. Holaday, of New York, Research Director of Socony-Vacuum Oil Company, Inc.

Productive Use Of Energies

This energy total is derived from petroleum, gas, coal, wood, and water power, but over half is contributed by petroleum alone. Holaday's comments are from a talk which he prepared for presentation before the Society of Automotive Engineers in Los Angeles on January 18. Because his airplane was grounded en route to California, the talk was not given. The points made are of considerable interest to our industry generally, however, Holaday urges conservation of our liquid fuel resources, as a matter of long-range national interest, for applications where no adequate substitutes are available, notably in the transportation field.

While petroleum will be relatively plentiful for an unspecified period, the Socony-Vacuum executive points out that this country, for the first time in its history, is importing a significant quantity of crude. Hence more care should be exercised in the selection of fuels for specific uses and greater consideration should be given to "the efficiencies involved in our consumption of natural resources."

Holaday asserts that the virtues of petroleum in certain fields, particularly transportation, demand that engineers redouble their efforts toward more efficient production and toward better utilization of fuels, even though their progress in this respect in recent years has been "outstanding." In addition, the engineers' efforts toward these objectives must be based upon a clear concept of the overall energy supply and demand situation "if this country is to continue to expand industrially and

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to continue to improve living standards for its own and the world's people." In the industrially still-growing United States alone, fuel requirements are increasing at a rate of 1,000 billion British thermal units per year.

Naturally-occurring energy sources—coal, petroleum, natural gas and shale—are ample for centuries to come, according to Holaday, but obtaining this energy economically in the state best adapted for effective utilization is a big problem for the engineers.

With regard to the nation's vast coal resources as a potential source of liquid fuels for the thirsty transportation field, Holaday warns that "petroleum resources cannot be supplemented tomorrow by this procedure," and continued—

"Within the next 10 to 20 years, synthetic processing costs will be reduced by expenditure of research and development efforts," he said. "In the meantime, other steps can logically be taken to reduce today's demand for liquid fuels and to extend their terms of availability."

Small Gas Turbine

ONE interesting and perhaps prophetic news item came last month from Boeing Airplane Company which reported during the recent SAE meeting in Detroit the development of a new 200-hp. gas turbine. Extracting from a paper by S. D. Hage of Boeing: "A small gas turbine can be a very neat and simple machine. The engine consists of a single stage centrifugal compressor with two outlets, two constant pressure burners, and a compressor driving turbine. This primary stage, or hot gas producer, has a rated speed of 36,000 rpm., and drives the accessories. The secondary or power output stage consists of another turbine with a rated speed of 24,000 rpm. and a 9.6:1 reduction gear giving a rated output speed of 2500 rpm. The speed of the primary stage is entirely regulated by the fuel flow, and the speed of the secondary stage is independently regulated by the load, and can be varied from stall to runaway or maximum safe speed.

"The weight of the engine without accessories is approximately 150 pounds. The power output will vary between 100 and 200 bhp., depending on the endurance life expected. The rated specific fuel consumption will vary between 1.5 and 1.0 lb./bhp.-hr., depending upon the rating and the degree of component refinement possible. The engine is extremely easy and consistent to start; it can develop rated power 15 seconds after the start is initiated. It can accelerate very rapidly, going from idle, which is about 10,000 rpm. to full speed in five seconds. It is practically vibrationless if the rotating parts are accurately balanced, destructively rough if not."

". . . the gas turbine cannot be stalled. The reciprocating engine torque falls to zero at zero speed. The Model 502 (the small turbine) stalled torque is twice the rated speed torque. Since such a load is very characteristic of most power requirements in the transportation field, land, water, and air, this type of engine is admirably suited without any complicating load varying devices. It should be emphasized (however) that a gas turbine without a free turbine is not very suitable for general application."

"Offsetting some of the desirable features of a small gas turbine, previously mentioned, are some features that should be discussed. The air consumption is very high, and large intake and exhaust friction losses are not tolerable. The author has not yet seen a clean solution to the compressor inlet noise problem. This silencing problem is especially difficult because of the large flow and the necessity for very low pressure drop. The idle fuel consumption is high, roughly one-fifth full power consumption. The development cost is high.

"However, it seems inescapable, that the small gas turbine will be a better solution to many of our power applications, than any we have now. These troublesome current problems, previously mentioned, will be solved. If the fullest advantage is taken of the reduction in engine and installation weight possible through the use of a simple engine, many vehicle applications can be better solved even in the face of the current fuel consumption. Production costs are unknown, but it seems most reasonable that they will be less per horsepower than reciprocating engines. In addition, the prospects for future improvement through development are very good, both as to fuel consumption and power weight-ratio.

"Current thinking should be concerned with honest evaluations of the benefits to be derived from the proper applications of the current engine. There is no doubt in the author's mind that many very valuable applications will be overlooked for some time because our thinking is so geared to past habits, and we are continually looking for something better on all counts. This is a new machine, and doesn't necessarily have to make our present vehicles better, but will result in different but better vehicles for the same transportation problem."

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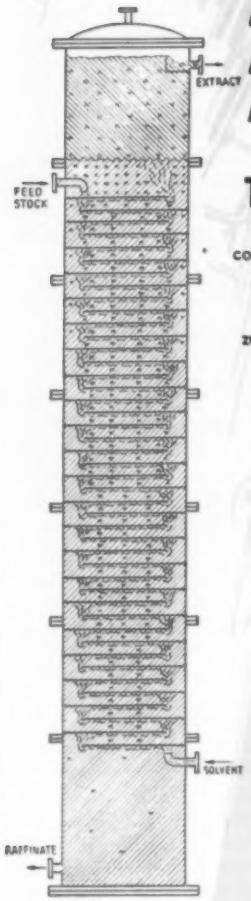
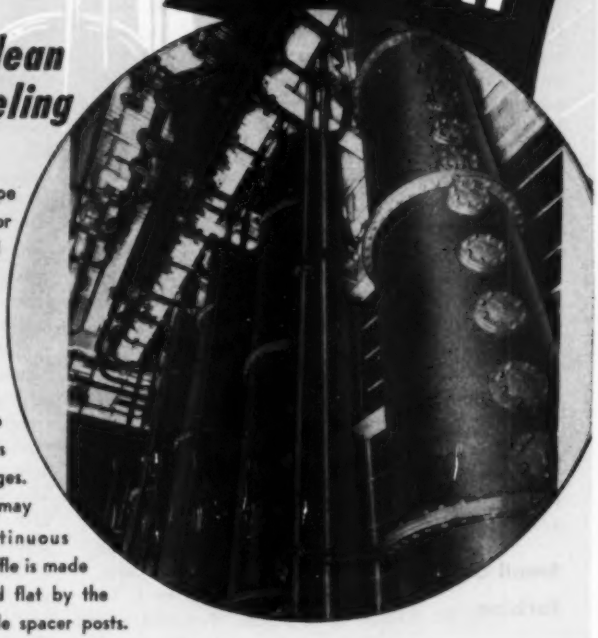


Diagrammatic sketch of a liquid-liquid extraction column



THE Vulcan baffle-type liquid-liquid extractor consists of a vertical column packed with a series of horizontal baffles. The turbulent region at the edge of each baffle serves to remix the liquids between stages. Either phase may be the continuous phase. Each baffle is made horizontal and flat by the use of adjustable spacer posts.

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Fuel and Power Sources If and When Oil Fails

Need seen for supplementing petroleum production with other sources of energy commencing in 10 to 20 years

R. J. S. PIGOTT
Chief Engineer, Gulf Research & Development Company
Pittsburgh

A YEAR or so ago some of the pessimists (or maybe they were only short on judgment) put out a very deceptive figure for the life of our supply of petroleum. It was obtained by dividing the proved reserves only by annual consumption, coming up with a life of about 12½ years.

However, published figures for the past decade show that proved reserves have been increasing at better than the annual consumption rate each year until the war. This means that the expected life by this method of calculation has stayed reasonably constant; about 10 years in 1937, 14 in 1942, and 11.5 years in 1946. It is picking up now, with resumption of war-delayed drilling. We should be justified then, if such a figure were sound, in assuming that petroleum would last forever, but such an estimate is even more absurd than the first one of 12½ years.

The fallacy is that such a method is oversimplified; it takes no account of a) unproved reserves, that is, all new, incompletely drilled fields; b) discoveries; and c) improved recovery in old fields.

Proved and Unproved Reserves

The known reserves are simply those which have been more or less completely drilled and in which we know closely the extent of the pools, sand thickness, porosity, etc. We have unproved reserves, that is, new pools that have been only partly drilled and not too much is known about exact definition of pool, sand body, etc. These reserves have been estimated from equal to the proved, up to 2½ times the proved. Annual discoveries, as finally proved up, have so far kept pace with annual consumption, but we know that this state cannot continue for long. Already about all the shallow pools have been found (1500 feet) and the average depth of new wells has increased from 3000 to 4000 feet, and an increasing part of the discoveries are at 10,000 feet and deeper. The new pools discovered each year clearly will diminish toward zero and they will continue to average deeper.

For the past generation we have been improving methods of total recovery by such processes as flooding with water to push out the oil, and repressuring. In the early days, recovery from a pool has been as low as 10 or 20 percent of the total oil in the sand; nowadays it is about 60 to 70 percent, and with improved primary and secondary methods applied, can go higher.

Taking into account the complete facts would indicate a pessimistic minimum of some 20 to 25 years at present consumption, a maximum of 40 to 50, and one cannot pin it down any closer. These figures include, for the maximum, consideration of increased efficiency in use of petroleum fuel in engines.

R. J. S. PIGOTT
Sketch on Author's Page 167

One thing is certain—whatever this country had as original oil, it has developed its resources at a very much higher rate than the rest of the world and therefore now has much less of its original supply than any other country. This country has supplied more than 60 percent of world consumption the last few years.

Engines of the Future

Before considering what other liquid fuel sources are possible of development, it would be well to consider the possible engines of the future, some of which will be available in 1949.

The obvious move for improvement in any engine efficiency is to improve the cycle on which it operates, that is, raise compression (and expansion) ratio. The move is already under way, and 1949 will probably see engines of somewhat higher compression ratio. These engines, rather carefully designed for better cooling than has been usual, will run on the present 85 to 92 Research octane premium fuels. For example, the saving by the ideal cycle for 7.75 c.r. is approximately 9 percent over 6..5 c.r. but the actual saving in the vehicle as operated is much higher—twice as much. The reason is that subsidiary savings are accomplished. The rise in c.r. increases indicated mean effective pressure, but the breathing and other engine losses do not materially increase, so that engine mechanical efficiency increases quite noticeably. In addition, if designed for the same brake horsepower, the engine is smaller and so are these engine losses. Further, the reduction of exhaust dilution by higher c.r. improves part-throttle efficiency. The purpose is, if possible, to move up to 12.5 c.r. as fuel becomes available. Experimental engines so far built need about 100-octane Research at 12.5 c.r., not available yet, and not likely to be, in large volume. The operating gain for this ratio is 35 to 40 percent over 6.5 c.r., worth trying for.

However, the increased octane value is only required if we increase compression ratio in a single stage, as in our present engines, and do nothing else. There are several ways in which the need for higher octane gasoline can be avoided. One is to employ the dual fuel idea offered in several forms. One form, the use of alcohol and water, is presently preparing for full-scale commercial trial, chiefly for trucks. Compression ratios of 8:1 or higher can readily be handled with this supplementary fuel, using 4 or 5 percent for peak octane demand, that is, near or at full throttle.

Turbo-Supercharger Idea

Another path is to extend the turbo-supercharger idea. If more power only were needed, supercharging as at present will get that easily; the real c.r. is the product of the supercharge ratio times the cylinder c.r., and unless something else is done, would require about the same octane value as the cylinder compression alone at 12.5 c.r. But since the compression is two-stage, with a supercharger, it is possible to apply an aftercooler between supercharger and engine, greatly reducing the octane demand of the engine by cooling the charge. We have proof this is so; a racing engine built 10 years ago was supercharged to 2.25 c.r. (17 psig.), cylinder ratio 6, over-all c.r. therefore 13.5. The aftercooler dropped temperature at engine inlet 60° and the unit ran on an 82 ASTM octane gasoline (of low sensitivity) without detonation. To get economy it would be necessary to increase expansion ratio equally, possibly by extending the turbo-supercharger idea and putting on a gas wheel big enough to use all the exhaust gas energy, which is more than that required to drive the blower. The set must then be geared to the engine. If we increase supercharge to something like 25 psig., we can use up all the engine exhaust energy for the blower and the turbo-supercharger need not be geared to the engine. But such a move will require a

considerable redesign of the engine, since average and heat temperatures rise considerably. The piston would undoubtedly require liquid cooling and better jacketing, and possibly improved valves are indicated. In effect, this is two-staging the expansion which is needed to get the economy; in supercharging only, the c.r. is raised but the expansion ratio remains that of the cylinder only, so there is no gain in economy.

It is quite possible that such a unit could be built cheaper than the same capacity unit without supercharger. The blower unit ought obviously to be cheaper per cubic inch of displacement than the much more complicated structure of the engine.

Another method of raising c.r. without raising octane demand has been proposed, but only developed so far in an experimental single cylinder unit. The proposal uses the diesel method of injection, with a controlled swirl in the cylinder so that no unburned mixture is ahead of the flame front, and detonation is not possible. This method has its attractive features, but it is not likely to give higher brake mean effective pressure than present diesels, and will therefore not improve weight per horsepower much.

"What Is in the Wood"

The best of the present engines for road-vehicles does not exceed 0.55 bhp. per cubic inch, unsupercharged aviation engines 0.70, supercharged aviation engines a little over 1.0; the racing engine mentioned above 1.5. This shows what is in the wood if we want to get it. Obviously, reduction of weight per horsepower, which accompanies increase of horsepower per cubic inch (or bmep., same thing, nearly), is valuable in permitting a reduction of weight in the whole chassis carrying the engine. There are more miles per gallon in lugging 2500 pounds deadweight around than 3000.

Other economies of a quite dissimilar nature are likely to be forced by the economic situation when petroleum becomes scarcer and more expensive. There has never been any reason for burning oil or natural gas in a central station except that these were cheaper than coal at the locality. About 3.8 percent of the electric power of the country is generated by fuel oil; about 10.3 percent by natural gas; 25 percent by water power; and 61 percent by coal. The elimination of the power generation from petroleum consuming would add about 10 percent to that now available for automotive uses.

The dieselization of railroads will change the balance of diesel fuel, but according to a study made by General Motors, should actually decrease the total oil now used by the railroads, since much of it is used in oil-fired steam equipment with a very much lower efficiency than the diesel units. The railroads are presently using about 7 to 7½ percent of the total petroleum supply and the above study indicates that their final use of diesel fuel should be something like 5½ percent on account of the increase of efficiency of using the diesel, and this would also release much of the 24 percent total coal produced for other purposes. In the event that the dieselization of railroads crowds the diesel fuel supply for other purposes, then it is perhaps possible to consider retaining steam equipment in storage so that if another war came on coal burning steam equipment could be put back into service, releasing diesel fuel for the armed services.

It is also possible that quite a good deal could be done in the future to improve the efficiency of the automotive vehicle. In spite of the relatively high fuel-load efficiency of the internal combustion engine, actually, as operated on the road, the load is for a very large percent of the time much less than maximum power and the efficiency is consequently very much worse. Heavy duty vehicles like buses and trucks operate at much better condition, better load factor, and work at better average efficiency than the passenger car. Improvement of part-throttle efficiency would improve this situation; reduction of losses between engine clutch shaft and tire surface on the road would be very advantageous. For example, a complete variable speed transmission of high efficiency which kept the engine speed down toward 1500-1800 rpm. most of the time, and with the throttle wide open, might save as much as 25 percent in gasoline consumption without any changes in the present engines.

Without going into details or any discussion of the authority of estimates, we can take a look at our present consumable sources of power and heat.

	Years Reserve at 1947 Total Consumption	
	Maximum	Minimum
Coal	1700	170
Petroleum	16	5
Natural Gas	12	5
Oil Shale	32	8
	1760	188

This table is prepared on the basis of *each* of the fuels being used for the whole energy supply for heat and power for 1947, so the whole can be added to arrive at a total energy supply. The huge difference between the maximum and minimum estimates is due principally to two factors: 1) We have in many cases greatly reduced the estimated reserves in coal by recent surveys, not yet complete; 2) the minimum estimates take into account *recovery* of these reserves, which is never 100 percent. Coal used to be about 50 percent, is now nearer 70 percent and may improve; oil was 10 to 20 percent, now nearer 70 percent and in some cases has reached 85 percent.

We do not know the ultimate reserves in oil, natural gas or oil shale because they have not been all discovered yet. In the case of oil shale, we do not know the efficiency of recovery.

One thing is certain; the safest estimate of resources will be down toward the minimum, and in any case, petroleum, natural gas and oil shale are relatively small in both estimates. It is therefore quite plain that if we are to get the requisite liquid fuel required for all automotive use, efforts should be directed to accomplish the following:

1) Designers should consider the transfer of all energy use possible to the solid fuel, from liquid, reserving liquid and gaseous fuels for those operations that cannot do without them.

2) Raise the efficiency of all heat and power transformations; the automobile has 5 percent over-all efficiency; utilities power generation is now 20 percent; steam locomotive 5 percent—pretty bad, but we know these can be raised and in many cases they are being raised now.

3) Determine the best methods for supplementary supply of liquid fuels, at the nearest to reasonable economic production and permanence. Much is being done on this now.

In addition, because there will be more time, we must study the replaceable or permanent sources of power; sun, air, water, earth-heat and wood.

Let us look at the permanent sources a moment. Collection of the heat of the sun has been experimentally developed and successful small plants are in operation. Such a source is intermittent and introduces the problem of heat or power storage, quite a difficult matter. Such plants as have been built or proposed involve a heavy initial cost that prevents economic soundness at present, except for a few special cases. The Sahara Desert has lots of heat, no water, no fuel; here even now, sun-collectors are justified. Tide and wave power has been the plaything of inventors for a century. You have heard of Passamaquoddy—the initial investment is what licks such proportions until fuels are much more expensive. The tide and wave power source does not look promising at present. A few such plants exist, leading a very precarious existence.

"Stumbling Blocks"

The ordinary hydro-electric plant is familiar, and expansion can undoubtedly proceed here to relieve the solid fuel. We have a total capacity in the country of about 50 million kw., of which some 10 million kw. has been built and is running. We can build the other 40 million kw. any time that the price of fuel makes the hydro competitive with the steam station for lower load factor. The reason no more hydro plants have been built is that, as in all the foregoing cases mentioned, the initial investment is much higher than that for a steam plant, enough so that unless the load factor exceeds 65 percent or so, the hydro total costs (operating and fixed charges) exceed those of a steam plant. The Buffalo General Electric Huntley Station, built at Niagara Falls in connection with one of the largest hydro developments in the country, has been enlarged several times since it was first built. Southern California Edison Company is another example. The major factor is that hydro power cannot exceed 50 million kw. capacity—that's all there is.

Referring to wind power, one fairly elaborate plant is being built to get operating data and performance. Again, investment and discontinuous operation are the present stumbling blocks.

All of the foregoing assist the electric power situation, but have no bearing on automotive fuel supply, except as they release fuel for automotive use.

Wood, a replaceable source, represents only 6 percent of the total energy used, mainly as space heating, and such power supply as can be conveniently obtained from wastes (sawdust, ends, bark) in the lumber processing and tanning industries. Much more power could be obtained from this source, waste products not only from lumber but paper and agriculture; in the lumber

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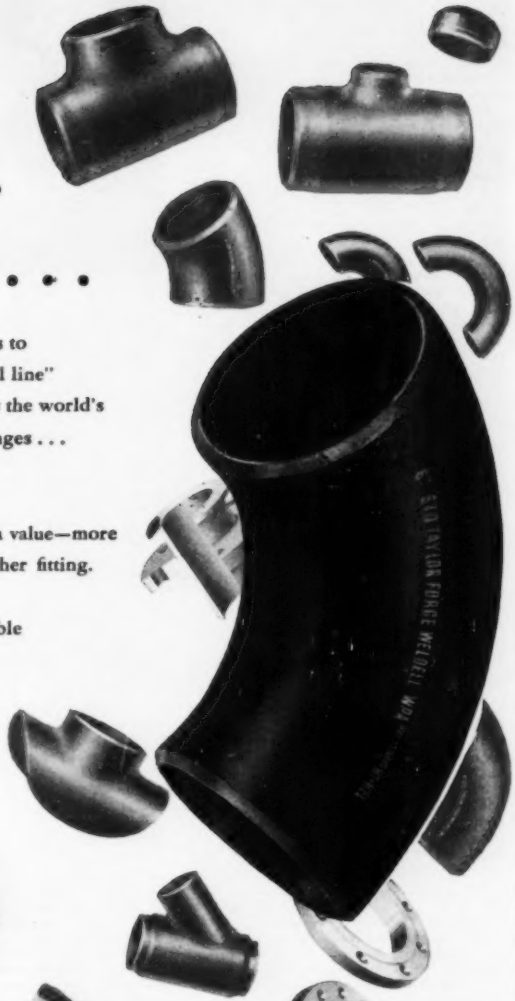

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industry the waste is still very large. We never have had any kind of adequate reforestation program even for replacement of straight lumber. Also, it should be pointed out that the use of agricultural products for fuels might serve to deplete our soil fertility.

Coming now to synthetic liquid fuels, the war and our own previous research have shown that we can produce gasoline from natural gas, coal, or crop products. The major difficulties are cost and low conversion efficiency. At present, gasoline from these sources would represent only 50 to 60 percent of the heat energy of the materials used to produce it, a tremendous loss of energy. Up to the present, we have not devised any method of synthesis of gasoline that does not cost considerably more than the cost of gasoline from petroleum. Two changes for the better can be expected, as ordinary technological development; the conversion efficiency will be improved, and the cost of the process reduced, gradually rendering the process more justifiable.

"Low Efficiency" Conversion of Gas

From the limited supply of natural gas, it seems inadvisable to load a low-efficiency conversion on top of present normal demand and growth. Gas is too valuable as gas to waste in this manner, and the complete depletion would only occur more quickly. Our other major reserve, coal, looks much the better supply for synthetic fuel. As mentioned above, wood is also a source of liquid fuel (as well as unconverted gaseous) and it has the supreme merit of being replaceable.

Nothing has been said about importing petroleum, particularly from the huge supply of the Near East. We are a net importer of crude for the first time. Undoubtedly we shall be importing greatly increased quantities of this crude in the next few years, but since another world war would, we must assume, cut off this supply, we cannot afford to base our domestic supply on this external source, but must be sure we can provide from within the country. Even South America, while safer than the Near East, cannot be regarded as a sure source, since it must ship by water or non-existent rail or pipe line. The shipment of any oil from foreign sources can be regarded only as easing our main problem, not solving it.

Shale oil is in much the same position as synthetics—low conversion efficiency, high cost. Even the optimistic estimates do not make our reserves of shale oil look much more than three times our original petroleum reserves and consideration of probable recovery would not justify much more than equal to oil; in fact, another relatively short-lived reserve.

Summing up, we must supplement our petroleum production with other sources, not tomorrow, but within a moderate space of years—10 to 20, say. Synthetic production costs will undoubtedly come down and petroleum products may go up. Consequently within a few years, schemes of synthetic production which now cost too much, may approach economic feasibility.

Shale oil and synthetics from coal have reached a possible production state and should receive the major development effort. This effort should be paralleled by development of synthetics from vegetable waste (lumber and other) and a reforestation program worked up to make the supply permanent. By this time, we should expect sun and wind power to be developed enough to take some of the load off coal, for diversion to synthetics.

Lubrication Problem

In the interest of economy, we look to increase of compression and expansion ratio. The important question then arises—what effect will this increase have, not only on fuel, but on lubrication?

The new single stage compression engines at 12.5 c.r. would require 100-octane Research and we can't make present full volume that high yet. We have two methods—dual fuel and after-cooled supercharging—which can run this high compression on the present gasoline. So we may feel this situation is under control.

The present diesel engines are running at compression rates of 13.0 and higher; the ring belt conditions are a trifle severer than most of the heavy-duty gasoline engines, but we are lubricating both quite successfully now. Diesel engine bearings are giving, if anything, less trouble than heavy-duty spark ignition engines. It is thought that this is mainly due to the much more general use of oil coolers, and more generous design. After looking over the whole trouble sheet, we cannot but arrive at the conclusion that the engine designer has control of the severity of the lubrication conditions in his design and we think he knows what to do. For keeping down octane demand (aside from supercharger aftercooling), a better job of jacket cooling, especially in controlled flow around exhaust valves; better cooled exhaust valve, probably sodium filled; cooler intake—all these are desirable and perfectly attainable. For safer lubrication, oil-cooled pistons, and a calculated lubricating system flow; more rigid structure to avoid misalignment and roughness—these give the rings and bearings a calculated life-expectancy and not an uninsured risk. In our opinion, the oils we have now will handle the higher compression engines of the future because the designers no longer expect a miracle oil to correct an inadequate design. It seems to us that the war accomplished one good thing—it showed both designers and oil producers more nearly *where* the effort should be spotted to make a design and a lubricant team up well.

ACKNOWLEDGMENT

Presentation of Mr. Pigott's study was before the January annual meeting in Detroit of the Society of Automotive Engineers.

Overseas Training Service Instructor Nouri Michael Mansy, an Iraqi, is shown watching his class in "spoken Arabic" take a few vocal exercises. All members of the class are Aramco employes.

Personnel Trained For Foreign Posts At New School

OIL company employes who will serve in industry posts abroad can now learn the language and customs of the country in which they will be stationed before leaving the United States. Overseas Training Service, a new company headed by George F. Dickover, on leave from Standard Oil Company (New Jersey), has set up a school, housing quarters and offices at Goshen, N. Y., and is offering "indoctrination" courses for men and women of several oil companies. OTS, incorporated about a year ago, already has graduated classes for International Petroleum Company, Tropical Oil Company, Standard Oil Company of Cuba and Arabian-American Oil Company.

The school is the idea of Dickover, formerly in charge of Creole Petroleum Corporation's industrial relations program at Aruba and in Venezuela. In 12 years' experience in the foreign field he became impressed with the fact that most industry personnel entering a foreign country for the first time are at a great disadvantage in not knowing the language and cultural ways of the people with whom they must live and work. Time lost by such employes in adjusting to their new physical and social environments is expensive for the companies involved, and often proves disagreeable to the employes themselves.

Companies Sponsor Students

OTS, set up with the intention of preparing employes for foreign service so they can fit in easily and quickly with their new conditions of work, has acquired a 30-room mansion, at Goshen, for class space and offices, and has effected arrangement with two hotels in

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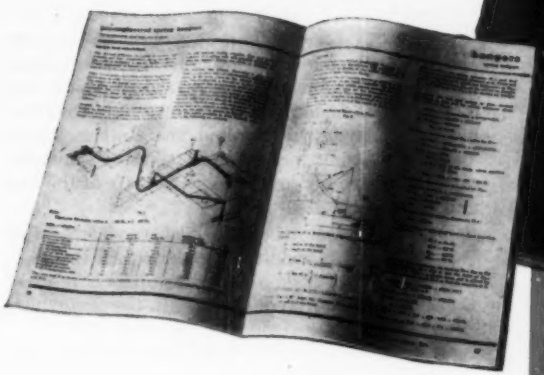

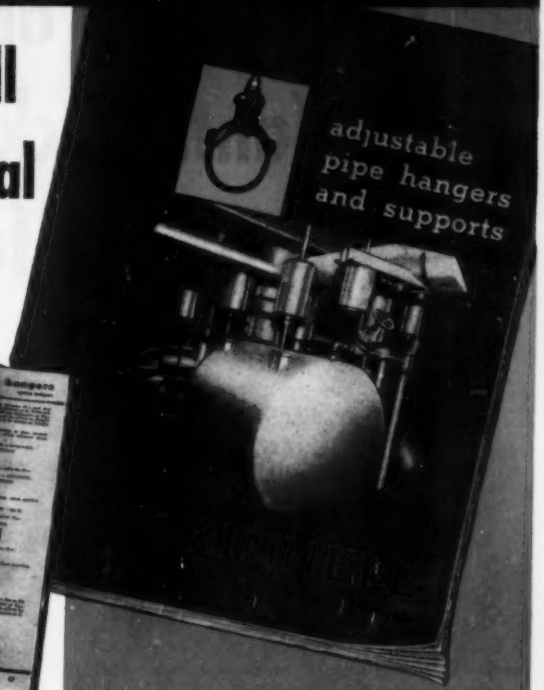

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Developing and proving "Ethyl" antiknock compounds of the future

FIVE MAJOR IMPROVEMENTS IN "ETHYL" ANTIKNOCK COMPOUND HAVE RESULTED FROM AN INTENSIVE AND EXPANDING RESEARCH PROGRAM

THE MANUFACTURER of antiknock fluid has an obligation to refiners to do far more than manufacture a compound. He must constantly improve his product and keep it up-to-date—in terms of the gasoline with which it will be blended—to insure maximum quality when added to the gasolines produced by the petroleum industry and used in the engines produced by the automotive industry. Thus technical advances in these two industries must be matched by equivalent advances in the formulation of "Ethyl" antiknock compound.

How well the Ethyl Research Laboratories have lived up to this obligation is indicated by the numerous changes—five of them major improvements—which have been made in "Ethyl" antiknock compound during the twenty-six years it has been marketed. Research aimed to make antiknock fluids of greater value to both refiner and ultimate consumer has been continuous and extensive.

There can be no stopping point in this research. As long as improvements continue to be made in fuels, lubricants and engines, the composition of antiknock compounds cannot remain static.

It is far from a simple project however, to keep pace with progress in the automotive and petroleum industries. When an antiknock compound is burned in an engine, much more is involved than the combustion of hydrocarbons and the suppression of knock. Each component of the antiknock compound may react with hundreds of components of the fuel and lubricating oil.

Further complicating the problem is the wide variety of engine conditions under which the gasoline containing the antiknock compound is used. Gasoline must work equally well in the family car,

CHEMICAL RESEARCH on antiknock compounds has been a continuous program at the Ethyl Laboratories for over twenty-five years.

GASOLINES CONTAINING new antiknock compounds are tested in laboratory engines under varying conditions of speed and load.

ENGINE PARTS are inspected before and after long tests involving changes in antiknock formulations.

the delivery truck, the high-speed bus and the farm tractor. Even after a superior "Ethyl" antiknock compound has been developed in the laboratory, a further long program is required to prove it satisfactory for all types of automotive service.

More than tetraethyllead

While tetraethyllead is the principal ingredient of "Ethyl" antiknock fluid, it is only one of a number of ingredients. Determining the most suitable other ingredients and their most effective proportions has always been a major part of the research program of the Ethyl Laboratories.

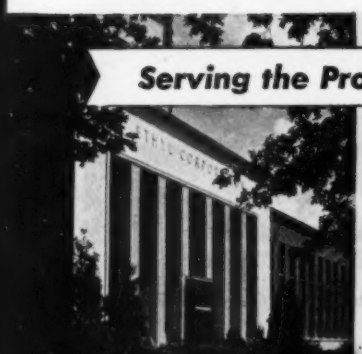
To this research Ethyl has devoted thousands of hours of engine studies in the laboratory, over ten million miles of test vehicle operation at the Detroit and San Bernardino Laboratories, and over four million miles of commercial vehicle operation in large truck and bus fleets operating under a wide range of conditions in different parts of the country and under the close supervision of Ethyl engineers. The last major change in "Ethyl" antiknock compound was made only after more than 17,000 hours of laboratory engine tests and over nine million miles of road tests had confirmed the desirability of the change.

Many research projects on experimental fluids are now in progress in the Ethyl laboratories. The aim of all this research is to provide for refiners antiknock fluids which give the most satisfactory engine operation and which give the greatest economy in the production of gasoline.

ROAD TESTS are made at Ethyl's San Bernardino laboratory to provide data on the road performance of experimental "Ethyl" fluids.

WHEN FAVORABLE RESULTS are indicated by dynamometer and vehicular research at the laboratory, new "Ethyl" fluid formulas are given final proof test in large commercial fleets.

This message is the eleventh in a series dealing with problems faced by refiners in producing gasoline for today's and tomorrow's engines, and the contribution of the Ethyl Corporation to their solution. Future messages will discuss other phases of this complex problem.



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RESEARCH LABORATORIES

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General assembly, or "chapel" period for O.T.S. students. Director George F. Dickover is presenting a chart talk on various phases of the oil industry abroad.

the resort town for the housing of "students." The plan operates only through employers; no one can enroll except those employed by a company and for whom the employer makes arrangements and pays costs.

The indoctrination course lasts for six weeks, with six hours of class work daily supplemented by private study on the parts of the students who live in rooms and apartments near the school. The program aims at imparting all necessary information on the country to which each employe is to be assigned, and a basic working knowledge of the language. In addition, general assembly sessions are held covering fundamental phases of the petroleum industry, particularly in its foreign operations. Information about a foreign country is imparted through the anthropological approach; guest informants who are natives of the country concerned lecture on phases of life in their own lands, with the principal objective of enabling Americans newly arrived in a strange country to avoid cultural blunders that often antagonize the nationals and embarrass the visitor.

The Language Program

OTS plans to expand its services to industries other than petroleum, and already has relations with the American International Association and the International Basic Economy Association. It has a staff of about a dozen active members and can call on the services of other experts as needed.

The language program is under direction of Dr. J. Milton Cowan, noted linguist, who developed the Army language training method during World War II. Dr. Merrill Y. Van Wagoner, head of the modern language department at Cornell University; and Dr. Howard W. Tessen of Yale University are on the faculty. This study is through the linguistic approach; students hear the language as spoken by a national instructor and then re-listen to the lesson on phonograph records in their rooms. So intensive is the course that graduates at the end of six weeks can use the tongue they have studied for all fundamental conversational purposes. Graduates master a working vocabulary of 2000 words in Spanish during the course, which is rated as the equivalent of a 6000-word "recognition" vocabulary; and acquire a vocabulary of 1000 words in Arabic for Middle East service. In addition, a thorough knowledge of the structure of a language is imparted, so that trainees can improve their spoken and written speech without the need of further instruction once they arrive in the foreign field.

Dr. Cowan and Ray Lebkicher of Arabian-American Oil Company visited Iraq last summer to prepare a language course in Araqi Arabic. The first class for Aramco was started at OTS in July, and other classes have been graduated since. The school will handle the language part of the Aramco training program at the oil company's new training center on Long Island. Recently Drs. Cowan and Van Wagoner have prepared a Saudi-Arabian Arabic course especially for Aramco employes. Two Saudi-Arabian nationals, both long-time employes of Aramco, have been flown to Goshen to assist.

"In some countries the use of the national language by supervisory personnel is a legal requirement," Dickover said. "We meet that need before the men go abroad. Furthermore, conditions generally demand that those working in a foreign country have a knowledge of the customs and institutions, cultural background and legislation. We meet these requirements with an integrated program of intensive instruction and general orientation.

"We start new groups every Monday and limit enrollment to a maximum of ten, thus assuring virtually personal attention to the trainees. Many of our students are married and bring their families with them to Goshen for the period of their six-weeks course. In fact, we allow the wives of trainees to attend limited sessions so they, too, can get a first grasp on the language of their new country."

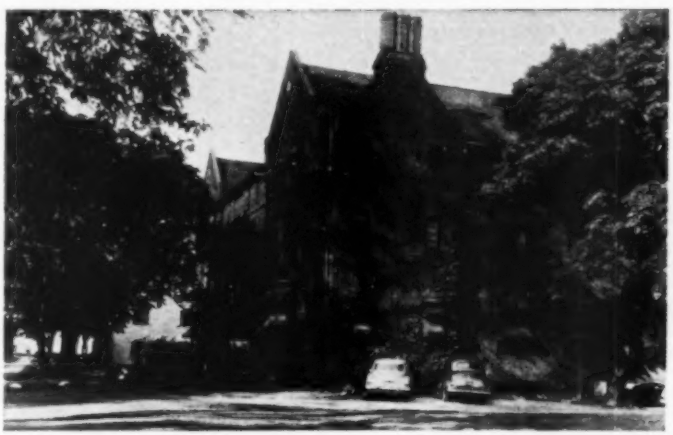
Weekly Progress Record

Topics covered in the course include, besides language, safety engineering, health problems, industrial questions, petroleum laws of the foreign countries, social legislation, mineral and oil resources of the countries, economic problems, and other technical subjects. OTS provides a weekly check record of each trainee for his employer.

Previous to organizing OTS, Dickover was in charge of industrial training for Creole at Aruba and later went to Venezuela where he organized Creole's program there. He set up Creole's training project at Maracaibo in 1945 and eventually was responsible for 13 different types of training work throughout Venezuela.

Dickover cites Creole's record as proof of the dollar value of indoctrination programs. Of one group of 515 employes hired by Creole, 371 were sent to training school while 144 went directly to jobs. Of those that passed through the school only 5.4 percent failed to remain in their subsequent jobs, but of those who did not have the training, 15.3 percent quit their jobs before contract expiration.

Overseas Training Service "dormitory" at Goshen, N. Y., famous resort spot known as the Goshen Inn, which is one of two quarters housing trainees during their six-weeks stay at the school.



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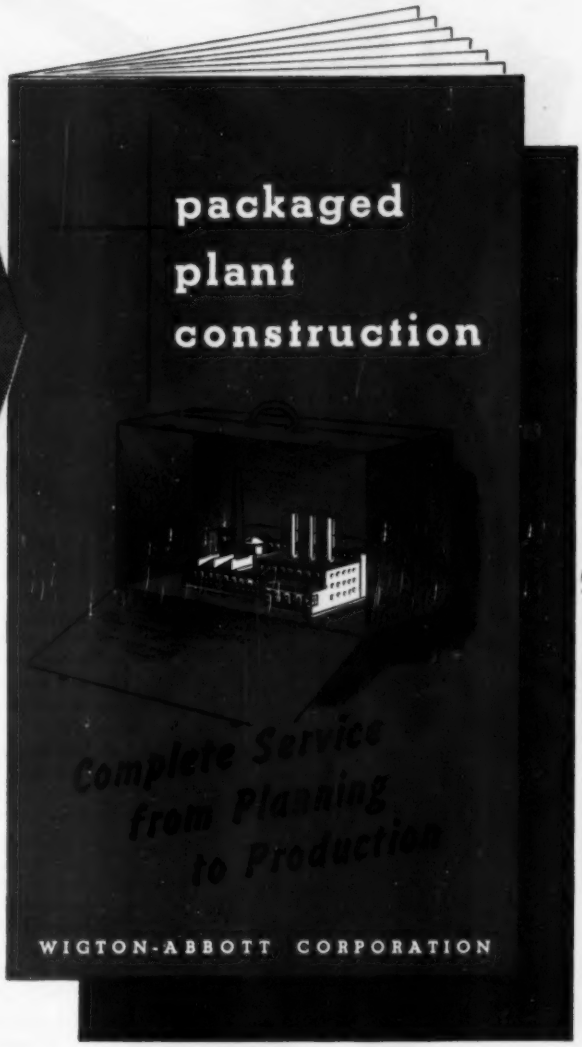

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REFINERY and Other PLANT CONSTRUCTION

Petroleum Refiner's exclusive feature which, in boxscore form, presents a quick picture of the tremendous amount of plant construction work that is in progress or projected by oil and other companies in all sections of the world.

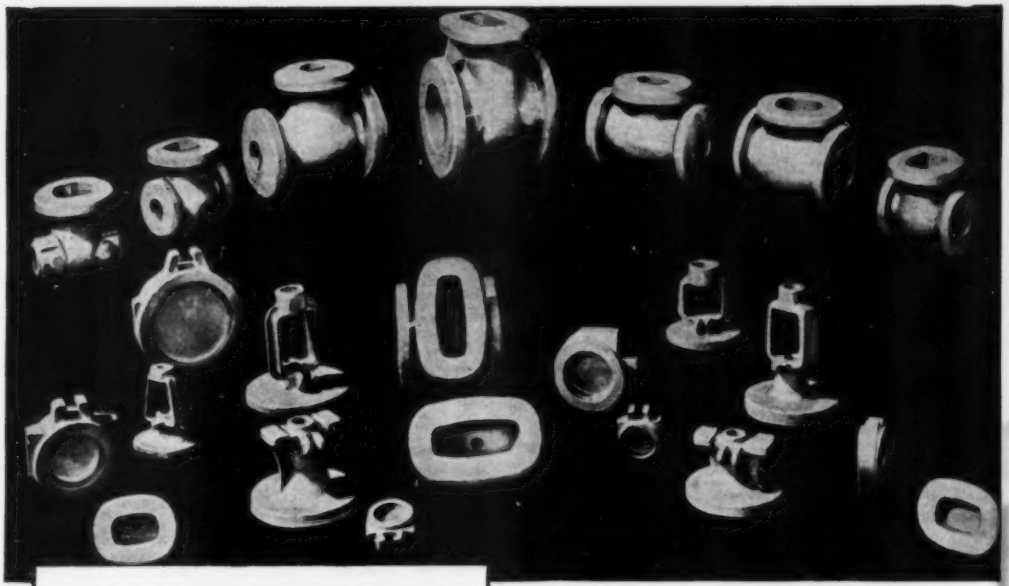
The tabulation presented each month under the heading "Refinery and Other Plant Construction" represents a continuing check of the building program that is in progress in the refining, natural gasoline and petrochemical industry. For a year and a half it has appeared as an exclusive feature in PETROLEUM REFINER and it has proved a valuable aid and guide to our readers.

Companies whose projects are not listed or readers who know of projects not listed are urged to: 1) send in data, as called for by the column headings, on units not shown herein; 2) furnish details which are missing in any items in the current tabulation, and 3) report from time to time on the progress of these projects. Address, Editor, PETROLEUM REFINER, Box 2608, Houston 1, Texas. Such cooperation will be very much appreciated.

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
EAST									
Esso Standard Oil	Linden, N.J.	Vac. pipe still	49,000 bbls.	.....	Under Constr.	1st Qtr., 1949	.....	S.O.D. & Braun	Braun
Esso Standard Oil	Linden, N.J.	Cat. Crack, Light Ends	41,000 bbls.	.....	Under Constr.	2nd Qtr., 1949	.....	S.O.D., Braun	Braun
Esso Standard Oil	Bayonne, N.J.	Dewaxing	7,500 bbls.	.....	Under Constr.	1st Qtr., 1950	Texaco	Badger	Badger
*Esso Standard Oil Co.	Linden, N.J.	Steam Boiler	280,000 lbs. hr.	.....	Under Constr.	1st Qtr., 1949	.....	S. O. D.	.....
*Esso Standard Oil Co.	Bayonne, N.J.	Steam Boilers	400,000 lbs. hr.	.....	Under Constr.	2nd Qtr., 1950	.....	S. O. D., Day & Zimmermann	S. O. D., Day & Zimmermann
Gulf Oil Corp.	Philadelphia, Pa.	Topping and Vacuum Unit	30,000 bbls.	.....	Under Constr.	Sept., 1949	.....	Lummus Badger	Lummus
Socony-Vacuum Oil Co., Inc.	Paulsboro, N.J.	Crude, Dist. Unit	20,000 bbls.	.....	Under Constr.	Mid 1949	.....	Badger	Badger
Socony-Vacuum	Paulsboro, N.J.	Propane Deasphalting	6,000 bbls.	.....	Under Constr.	Mid 1949	Juik	Badger	Badger
Socony-Vacuum	Paulsboro, N.J.	Furfural Refg.	4,450 bbls.	.....	Under Constr.	Mid 1949	Texaco	Badger	Badger
Socony-Vacuum	Paulsboro, N.J.	MEK Dewaxing	2,050 bbls.	.....	Under Constr.	Mid 1949	Texaco	Badger	Badger
Socony-Vacuum	Paulsboro, N.J.	Clay Contact Unit	.....	.....	Designing	Late, 1949	.....	Badger	Badger
Socony-Vacuum Oil Co., Inc	Paulsboro, N.J.	Light Oil Treating Plant	27,000 bbls.	.....	Designing	Mid 1949	.....	Badger	Badger
L. Sonneborn Sons, Inc.	Petrolia, Pa.	Enlarge Acid Plant, Anti-Pollution	.....	$400,000	Under Constr.	Middle 1949	.....	Chemical Constr. Co.	Morris Knowles & Co.
Sun Oil Co.	Marcus Hook, Pa.	Wax	.....	.....	Under Constr.	1949	Texaco	Staff	Staff
Sun Oil Co.	Marcus Hook	Comp. & Pkg.	.....	.....	Under Constr.	1949	.....	Staff—Lindsay	W. W. Lindsay
The Texas Co.	Beacon, N.Y.	Expand Research Labs.	.....	.....	Under Constr.	Oct., 1, 1949	.....	Voorhees, Walker, Foley & Smith	.....
The Texas Co.	Westville, N.J.	New Refinery	40,000 bbls.	.....	Under Constr.	July, 1949	.....	Foster-Wheeler, Jackson-Moreland, Kellogg	Foster-Wheeler, Kellogg
Tide Water Associated Oil Co.	Bayonne, N.J.	Revamping Houdry Fixed Bed Unit	.....	.....	Under Constr.	.....	Houdry	Houdry	Cat. Constr.
U. S. Dept. of Interior	Bruceton, Pa.	Fischer-Tropsch Pilot Plant (Coal-to-gasoline synthesis)	1-2 bbls.	$150,000	Under Constr.	June, 1949	.....	Staff	Blaw-Knox Co.
MID-CONTINENT									
Ashland Oil and Refining Co.	Ashland, Ky.	Revision & Modernization of Refg. Units	.....	$500,000	Under Constr.	Jan., 1949	.....	Staff	Staff
Cities Service Oil Co.	Chicago	Compounding & Grease Plant	1,500 bbls.	$2.5 million	Design	Late 1949	.....	Sumner-Sollitt	.....
Cooperative Refinery Association	Coffeyville, Kansas	Dewaxing	2,200 bbls.	$1.5 million	Contracted	1949	Texaco	Process Eng.	Process Eng.
*Cooperative Refinery Assoc.	Coffeyville, Kansas	Modernize Gasoline Plant	20,000 bbls.	$900,000	Under Constr.	June, 1949	U.O.P.	U.O.P., Staff	Staff
Continental Oil Co.	Ponca City, Oklahoma	Repair & Revision to Cat. Crackers	22,500 bbls.	$944,000	.....	Completed	Houdry	Cat. Constr.	Cat. Constr.
Continental Oil Co.	Ponca City, Oklahoma	Crude Dist. Unit	30,000 bbls.	.....	Under Constr.	Oct., 1949	.....	Bechte	Bechtel
Dewese Oil Co.	Weston, Ohio	Lube Filtering Unit, Desalting	250 bbls.	$15,000	Under Constr.	Spring, 1949	.....	Staff	Staff
The Globe Oil & Refining Co.	Lemont, Ill.	Cat Cracker Unit	6,000 bbls.	$1 million	Buying Material	Jan. 1, 1950	U.O.P.	U.O.P.	.....
Gulf Refg. Co.	Toledo, Ohio	Top & Vac. Unit	32,000 bbls.	.....	Under Constr.	March, 1949	.....	Badger	Badger
Gulf Refg. Co.	Toledo, Ohio	Fluid Cat. Crk.	15,500 bbls.	.....	Under Constr.	May, 1949	.....	Kellogg	Kellogg
Gulf Refg. Co.	Toledo, Ohio	Poly Unit	5,000 bbls.	.....	Under Constr.	May, 1949	U.O.P.	Kellogg	Kellogg
Gulf Refg. Co.	Cincinnati, Ohio	Fluid Unit	15,500 bbls.	.....	Under Constr.	June, 1949	.....	Kellogg	Kellogg
Gulf Refg. Co.	Cincinnati, Ohio	Polymer Plant	5,000 bbls.	.....	Under Constr.	June, 1949	U.O.P.	Kellogg	Kellogg
Hiwan Oil Co.	Magnolia, Ark.	Gasoline Plant	10,000 mcf	.....	Part Completed	.....	.....	Petro. Eng.	Petro. Eng.
Lion Oil Co.	El Dorado, Ark.	Enlarge Ammonia Unit	570 tons	$2.5 million	Under Constr.	June, 1949	.....	Chem. Constr.	Chem. Constr.

REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Lion Oil Co.	El Dorado, Ark.	Sulfuric Acid Plant	300 tons	$1¼ million	Under Constr.	Sept., 1949		Chem. Constr.	Chem. Constr.
Lion Oil Co.	El Dorado, Ark.	Ammonium Sulfate Plant	380 tons	$750,000	Under Constr.	Sept., 1949		Chem. Constr.	Chem. Constr., Blaw-Knox
M. F. A. Oil Co.	Chanute, Kans.	Desulfurization	1,000 bbls.	$75,000	Under Constr.	June, 1949	Phillips	Koch	Staff
Magnolia Pet. Co.	Grant County, Kans. (Hickok)	Gasoline Plant	100,000 mcf		Buying Material	Nov., 1949		Staff	Waico
Magnolia Pet. Co.	Grady County, Oklahoma	Gasoline Plant	30,000 mcf		Design	Sept., 1949			
Magnolia Petroleum Co.	Stephens County, Okla.	Gasoline Plant	30,000 mcf		Under Constr.	Nov., 1949			
Mercury Oil Refining Co.	Oklahoma City, Oklahoma	Crude Unit	3,500 bbls.	$250,000	Under Constr.	Dec., 1949		Ref. Eng.	Ref. Eng.
Midland Cooperative Wholesale	Cushing, Okla.	Thermal Reforming	1,400 bbls.	$500,000	Under Constr.	March, 1949	U.O.P.	U.O.P., Ref. Eng.	Ref. Eng.
Ohio Oil Co.	Robinson, Ill.	Vac. Unit Cat. Crack, Crude Still, Poly, LP G Recovery	27,500 bbls.	$15 million	Under Constr.	Early, 1949	U.O.P.	McKee	McKee, Pritchard
Petco Corp.	Blue Island, Ill.	Cat. Cracker Unit, LPG Recovery System	5,000 bbls.	$400,000	Under Constr.		Houdry		Clark's
Phillips Pet. Co.	Kansas Cy, Kans.	Cat. Crack	24,000 bbls.		Under Constr.	Oct., 1949		Braun	Braun
Phillips Pet. Co.	Kansas Cy, Kans.	Cat. Poly	1,500 bbls.		Under Constr.	Oct., 1949		Braun	Braun
Phillips Pet. Co.	Guymon, Okla.	Absorption Plant	173,000 mcf		Authorized	July, 1949			
Rock Island Refg. Corp.	Rock Island, Ind.	Fluid Cat, Crk.	10,000 bbls.	$1,200,000	Contracted	July, 1949	U.O.P.	U.O.P.	Staff
The Shallow Water Refining Co.	Shallow Water, Kansas	Reforming Unit	1,250 bbls.	$85,000	Materials Ordered	Fall, 1949	Pureo	Koch Eng.	Koch Eng.
Skelly Oil Co.	Eldorado, Kans.	Crude Dist. Unit, Cat. Crk.	35,000 bbls.		Under Constr.	Mid 1950			
Socony-Vacuum	E. St. Louis, Ill.	Cruce Distillation	20,000 bbls.		Under Constr.	Aug., 1949		Bechtel Staff	Bechtel
*Socony-Vacuum Oil Co.	East St. Louis, Illinois	Thermal Cracking, Reforming, Visbreaker Unit	15,000 bbls.		Under Constr.	Oct., 1949		Staff, Bechtel	Bechtel
*Socony-Vacuum Oil Co.	East St. Louis, Illinois	Tannin Solutiser Treating Unit	20,000 bbls.		Under Constr.	June, 1949		Staff, Bechtel	Bechtel
*Socony-Vacuum Oil Co.	East St. Louis, Illinois	Miscl. Refinery Additions			Under Constr.	Sept., 1949		Staff, Bechtel	Bechtel
*Socony-Vacuum Oil Co.	East St. Louis, Illinois	Delayed Coking Unit	8,700 bbls.		Under Constr.			Staff, Bechtel	Bechtel
Standard Oil Co., (Ohio)	Lima, Ohio	Lube Oil Solvent, Refining Plant	76,000 gals.	$13 million	Contracted	1951		Kellogg, Lummus	Kellogg, Lummus
Standard Oil Co., (Ohio)	Lima, Ohio	Cat Cracking	16,000 bbls.	$11 million	Under Constr.	Late 1949	U.O.P.	McKee	McKee
Standard Oil Co., (Ohio)	Lima, Ohio	Crude Distl., Coke	†15,000 bbls.	$5 million	Authorized	Mid 1950	Kellogg	Kellogg	Kellogg
Standard Oil Co., (Ohio)	Lima, Ohio	Solvent Extraction Dewaxing Unit	1,800 bbls. Finished Products		Authorized	Mid 1950	Texaco		Lummus
Standard Oil Co., (Ohio)	Lima, Ohio	Vacuum Unit	9,000 bbls.		Authorized	Mid 1950			Lummus
Standard Oil Co., (Ohio)	Lima, Ohio	Propane Desphalting Unit	800 bbls.		Authorized	Mid 1950			Lummus
Stanolind O&G Co.	Ulysses, Kans.	Gasoline Plant	100,000 mcf		Under Constr.	March, 1949		J & L Constr.	J & L Constr.
Sun Oil Co.	Toledo, Ohio	Cat. Crack Crude Dist., Vac., Poly	30,000 bbls.	$16 million	Under Constr.	1950	Houdry	Houdry, Cat. Constr., Process Eng., Staff	Cat. Constr.
Sun Oil Co.	Toledo, Ohio	Anti-Pollution	600,000		Under Constr.	1949		Sun Oil	Cat. Constr.
The Texas Co.	W. Tulsa, Okla.	Crude and Cat. Cracking	30,000 bbls.		Under Constr.	July, 1, 1949		Kellogg, Foster-Wheeler, U.O.P.	Kellogg, Foster-Wheeler
The Texas Co.	Lawrenceville, Illinois	Expand Refinery	†20,000 bbls.		Proposed	Jan. 1, 1951			
Tide Water Associated Oil Co.	Drumwright, Oklahoma	Houdriflow Unit Cat. Cracker	4,500 bbls.		Contracted		Houdry		Process Eng.
*U. S. Bureau of Mines	Louisiana, Mo.	Synthetic Liquid Fuels Plant	200 bbls.		Under Constr.			Staff, Bechtel	Bechtel
U. S. Dept. of Interior	Louisiana, Mo.	Demonstration Oil-from-Coal Plant	75 bbls.	$4.4 million	Under Constr.	Oct., 1949		Koppers	Koppers
Warren Pet. Corp.	Madill, Okla.	Gaso. Plant Enlargement	25,000 bbls.			Completed		Hudson	Hudson
Warren Pet. Corp.	Maysville, Okla.	Gasoline Plant	8,000 bbls.		Under Constr.	Mar. 15, 1949		Dresser	Dresser
Wood River Oil & Refg. Co.	Hartford, Ill.	Cat. Cracking Gasoil Cracking	8,500 bbls.	$1 million	Under Constr.	March, 1949	Phillips	Koch Eng.	Koch Eng.
SOUTHWEST									
*American Republics Corp.	Silsbee Field, Texas	Gas Compression, Absorp.				Completed			
The Atlantic Refining Co.	Port Arthur, Texas	Increase Capacity	42,300 bbls.			Completed		Staff	Staff
The Atlantic Refining Co.	Block 31, Crane County, Texas	Gas Injection Plant	8,320 mcf		Under Constr.	May, 1949		Hudson, Staff	Hudson
Barnsdall Oil Co.	West Tepetate Field, La.	Gasoline Plant	20,000 mcf	$800,000	Under Constr.	Middle 1949		Dresser	Dresser
Barnsdall Oil Co.	McFadden Field, Texas	Gas Compressor Plant	7,000 mcf			Completed		Olsen	Olsen
The California Co.	Brookhaven, Mississippi	Cycling Plant	10,000 mcf		Designing	3rd Qtr., 1949		Hudson	Hudson
*Calumet Ref. Co.	Princeton, La.	Blending Oil Tank House	700 bbls.		Under Constr.	3rd Qtr., 1949			Staff
Carthage Corp.	Carthage, Field	Gasoline Plant	250,000 mcf	$3.5 million	Under Constr.	March, 1949		Hudson	Hudson
Carthage Hydrocol, Inc.	Brownsville, Texas	Hydrocol	87,000 mcf	$26 million	Under Constr.	Aug., 1949	Hydro-Res., Inc. Texaco	McKee, Hydro-Res., Inc.	McKee
The Chicago Corp.	Carthage, Texas	Enlarge Gas Pl	210,000 mcf	$2 million	Under Constr.	June, 1949		Fish Eng.	Fish Eng.
*Cinco Hydrocarbon Co.	Woodson, McKnight Fields, Texas	Gas Compression, Absorp.				Completed			
Cit-Con Corp.	Lake Charles, La.	Lube Plant	6,000 bbls.	$35 million	Under Constr.	Oct., 1949	Texaco, Max B. Miller	Max B. Miller, Lummus	Lummus, Max B. Miller
Cities Service Oil Co.	Pampa, Texas	Gasoline Plant	18,000 mcf		Contracted	1949		Waico	Waico
*Cities Service Oil Co.	Chico Field, Wise Co., Tex.	Natural Gasoline Plant	22,000 mcf		Planned	Early, 1950			
Claiborne Gasoline Co.	Lisbon, La.	Enlarge Gasoline Plant	125,000 mcf		Under Constr.	March, 1949		Pet. Eng.	
Continental Oil Co.	Sonora, Texas	Gasoline Plant	10,000 mcf	$2.5 million	Contracted	July, 1949		Ref. Maint.	Ref. Maint.



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Cast steels containing 0.15% maximum carbon and 3½% nickel have shown an inherent toughness exceeding 15 foot-pounds Charpy (keyhole notch) impact resistance at temperatures down to minus 150° F. In this class are the valves and fittings, shown above, cast by Fort Pitt Steel Casting Division of Pittsburgh Steel Foundry Corp., McKeesport, Pa.

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- Dewaxing equipment
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- Valves and fittings for high temperatures
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- Return bends
- Floating tube heads
- Miscellaneous heat exchange parts
- Pump parts

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of Alloyed Over Plain Carbon Steel Castings

1. STRONGER...HIGHER YIELD STRENGTH
2. LESS BULK AND DEADWEIGHT
3. BETTER RESPONSE TO HEAT TREATMENT
4. GREATER SHOCK RESISTANCE
5. GREATER FATIGUE STRENGTH
6. LESS EMBRITTLEMENT AT SUB-ZERO TEMPERATURES
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REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

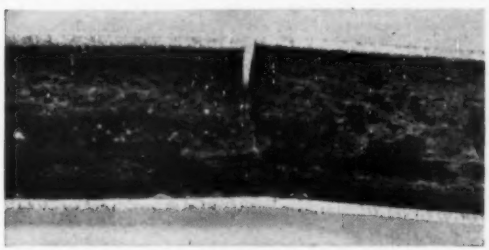
COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Continental Oil Co.	Todd (Deep) Field, Texas	Gas Recovery Plant	80,000 gals.	.....	Under Constr.	Sept., 1949	.....	Ref. Maint.	Ref. Maint.
Cordon Pet. Corp.	Big Spring, Tex.	Fluid Cat. Plant	6,000 bbls.	$2 million	Under Constr.	Nov., 1949	U.O.P.	U.O.P.	Ref. Eng.
El Paso Natural Gas Co.	Goldsmith, Tex.	Gas Treat, Plant	70,000 mcf	$603,700	.....	Completed	.....	Fluor	Staff
Esso Standard Oil Co.	Baton Rouge, La.	Light Ends Recovery	20,000 mcf	.....	Under Constr.	1st Qtr., 1949	.....	S.O.D., McKee	McKee
Esso Standard Oil Co.	Baton Rouge, La.	Light Ends	11,000 bbls.	.....	Under Constr.	1st Qtr., 1949	.....	Braun	Braun
Ethyl Corp.	Baton Rouge, La.	Mfg. Facilities	.....	$40 million	Under Constr.	Oct., 1949	.....	Stone & Webster	Stone & Webster
Gray-Wolfe Co.	Montgomery Co.	Gasoline Plant	12,000 mcf	$2 million	Under Constr.	March, 1949	.....	O. L. Olsen	O. L. Olsen
Gulf Oil Corp.	Crane, Texas	Gasoline Plant	40,000 mcf	.....	Contracted	Fall, 1949	.....	Braun	Braun, W. D. Bowden
Humble O&R Co.	Katy, Texas	Add Propane, Absorption, refrigeration	Unchanged	$7 million	Under Constr.	Oct., 1949	.....	Stearns-Roger	Stearns-Roger
Humble O&R Co.	Kelsey Field, Texas	Gas Injection Plant	18,000 mcf	$1,408,000	Under Constr.	May, 1949	.....	Stearns-Roger	Stearns-Roger
Humble O&R Co.	Borregne-Seeligson, Tijerina-Canales Fields, Texas	Gas Injection Plant	30,000 mcf	$1,338,000	Under Constr.	March 1, 1949	.....	Stearns-Roger	Stearns-Roger
Humble O&R Co.	Conroe, Texas	Add Compression—Absorption	30,000 mcf	$4,160,000	Under Constr.	Summer, 1949	.....	Stearns-Roger	Stearns-Roger
Humble O&R Co.	Heyser Field Texas	Gas Comp. Plant	23,000 mcf	.....	Under Constr.	April, 1949	.....	Belloo Ind. Piping Co.	Belloo Ind. Piping Co.
Humble O&R Co.	Opelousas, La.	Absorption Plant	110,000 mcf	$2,800,000	Under Constr.	Summer, 1949	.....	Hudson	Hudson
Humble O&R Co.	Pinkton Field, Texas	Gas Injection—Absorp. Plant	18,000 mcf	$3,132,000	Under Constr.	June, 1949	.....	Fluor	Fluor
Humble O&R Co.	Baytown, Texas	Pipe Stills	45,000 bbls.	$5.8 million	Under Constr.	Late 1949	.....	Foster-Wheeler	Foster-Wheeler
Humble O&R Co.	Baytown, Texas	Lube Extraction	7,000 bbls.	$5.3 million	Under Constr.	Late 1949	.....	Kellogg	Kellogg
Humble O&R Co.	Flour Bluff Field, Texas	Compression Plant	12,500 mcf	.....	Under Constr.	April, 1949	.....	Tellepsen	Tellepsen
Humble O&R Co.	Imogene-Jourdanton-Charlotte Fields Texas	Compression Absorption Plt.	26,000 mcf	.....	Authorized	1949-1950	.....	.....	.....
*Humble O.&R. Co.	Thompsons, N. Thompsons, S. Thompsons Field, Texas	Gas Compression Plant	15,500 mcf	.....	Under Constr.	June, 1949	.....	Brown Eng.	Brown Eng.
Jefferson Chem. Co.	Austin, Texas	Central Research Facilities	.....	.....	Design	1949	.....	.....	.....
La Gloria Corp.	Falkurrias, Tex.	Casinghead Gas	20,000 mcf	.....	Under Constr.	May, 1949	.....	Hudson	Hudson
Lone Star Gas.	Dallas, Texas	Hypersorption Plant	60 mcf	.....	Design & Eng.	1949	Union Oil Co.	Foster-Wheeler	Foster-Wheeler
Magnolia Pet. Co.	Beaumont, Tex.	Lube Plant	.....	.....	Under Constr.	March, 1949	Texaco	Lummus	Lummus, Kellogg
Magnolia Pet. Co.	Seeligson Field, Texas	Gasoline and Cycling	170,000 mcf Casinghead 150,000 mcf Cycled	.....	Under Constr.	Sept., 1949	.....	Hudson	Hudson
*Magnolia Pet. Co.	Kilgore, Texas	Increase Propane Recovery	Unchanged	.....	Under Constr.	April, 1949	.....	Staff, Delta	Delta
*Midland Gasoline Co.	Conroe Field, Texas	Enlarge Gasoline Plant	100,000 gals.	.....	Under Constr.	Dec., 1949	.....	Gaso. Plant	Gaso. Plant
Natural Gaso. Corp.	Hawkins, Tex.	Enlarge Plant	20,000 gals.	.....	Under Constr.	Completed	.....	Gaso. Plant	Gaso. Plant
*Nueces Corp.	Agua Dulce Field, Texas	Gas Compression	.....	.....	Under Constr.	April, 1949	.....	.....	.....
Paluxy Asphalt Co.	Yazoo City, Miss.	Cracking Still	1,500 bbls.	$125,000	.....	Completed	.....	.....	Self
Paluxy Asphalt Co.	Yazoo City, Mississippi	Gas Recovery Cat. Polymer Unit	3½ mcf	$250,000	Under Constr.	March, 1949	U.O.P.	Koch	Staff
Pan American Refining Corp.	Texas City, Texas	Expand chemical Research Facilities	.....	.....	Contracted	Jan., 1950	.....	Staff, H. K. Ferguson	Staff, H. K. Ferguson
Panhandle Producing & Refg. Co.	Wichita Falls, Texas	Cat. Cracker	1,500 bbls.	$1 million	Engineering	March, 1950	U.O.P.	U.O.P., J & L Constr.	J & L Constr.
*Panhandle Producing & Ref. Co.	Agua Dulce, Texas	Gas Compressor	5,000 mcf	$300,000	Under Constr.	Feb., 1949	.....	Staff	D. C. Thompson
The Parade Co.	Rusk County, Texas	Add Propane Recovery	18,000 mcf	$350,000	Under Constr.	March, 1949	.....	Hudson	Hudson
Petrol Refining, Inc.	Texas City, Texas	Crude Topping Units	80,000 bbls.	.....	Under Constr.	April 1, 1949	.....	Rust. Eng.	Rust. Eng.
Phillips Pet Co.	Alvin, Texas	Absorption Plant	120,000 mcf	.....	Authorized	Sept., 1949	.....	.....	.....
Phillips Pet. Co.	Etter, Texas	Petro-chem. Plant Increase	140,000 tons yr.	.....	Authorized	.....	.....	Chem. Constr.	.....
Phillips Pet. Co.	Goldsmith, Tex	Add to Absorption Plant	40,000 mcf	.....	Under Constr.	April, 1949	.....	.....	.....
*Plymouth Oil Co.	Benedum Field, Texas	Gas Compression, Absorp.	.....	.....	Under Constr.	1949-50	.....	.....	.....
The Pure Oil Co.	Nederland, Tex.	MEK Dewaxing Clay Contact	2,500 bbls.	.....	Under Constr.	March, 1949	Texaco	Lummus	Lummus
The Pure Oil Co.	Nederland, Tex.	Deasphalting, Phenol Extrac.	4,300 bbls.	.....	.....	Completed	Juik	Kellogg	Kellogg
The Pure Oil Co.	Nederland, Tex.	MEK Dewling	200 bbls.	.....	Under Constr.	Sept., 1949	Texaco	Lummus	Lummus
The Pure Oil Co.	Nederland, Tex.	Compound, Blending	1,500 bbls.	.....	Under Constr.	March, 1949	.....	Staff, Verne E. Alden	Stone-Webster
The Pure Oil Co.	Nederland, Tex.	Grease Plant	66,000 lbs.	.....	Under Constr.	March, 1949	.....	Staff, Verne E. Alden	Stone-Webster
Shamrock Oil & Gas Co.	Sunray, Texas	Increase Topping & Cracking Facilities	10,000 bbls.	$300,000	Under Constr.	3rd Qtr., 1949	U.O.P.	Staff	Staff
Sid Richardson Gasoline Co.	Keystone Field, Texas	Gasoline Plant	107,000 mcf	.....	Under Constr.	March, 1949	.....	J & L Constr.	J & L Constr.
*Sinclair Prairie Oil Co.	Midway Lane Field, Texas	Gas Compression	.....	.....	Under Constr.	Early, 1949	.....	.....	.....
Shell Chem. Corp.	Houston, Texas	Extend Acetone Facilities	.....	.....	Under Constr.	Late 1949	.....	Braun	Braun
Shell Oil Co.	Notrees, Texas	Extension TXL Plant	30,000 mcf	.....	Under Constr.	Early 1950	.....	Brown & Root	Brown & Root
Skelly Oil Co.	Skellytown, Tex.	Expand Gasoline Plant	.....	.....	Under Constr.	Fall, 1949	.....	.....	J. E. Carlson
*Shell Oil Co.	Denver City, Texas	Gas Compression, Absorp. Addition	30,000 mcf	.....	Under Constr.	Late, 1949	.....	Fluor	Fluor
*Southern Minerals Corp.	Stratton Field, Texas	Gas Compression Addition	.....	.....	Under Constr.	1st Qtr., 1949	.....	.....	.....

Lengthening Tube Life

Combating the Effects of Ammonia and Vibration

Condenser and heat exchanger tubing in the chemical, petro-chemical and refining industries is subjected to exceptionally severe corrosive conditions. Copper-base alloys, in most cases, successfully resist corrosion from both the water side as well as from the product side of the tubes. However, where ammonia or nitrogen compounds capable of producing ammonia come in contact with the tubes, season cracking of susceptible brasses may take place. This is similar to the type of cracking which may occur under certain conditions with other metals – carbon steel when affected by certain caustic solutions, stainless steel by acid chlorides, aluminum and magnesium by sea water, plastics by certain solvents, rubber by oxidation, etc.

Effect of Alloy Composition. With conditions which may lead to season cracking of brass, we suggest the use of Copper or Cupro Nickel which are most resistant to this type of attack. Aluminum Bronze and Red Brass are next in order, while hard-drawn Admiralty, Aluminum Brass and Muntz Metal alloys are least resistant to season cracking.



Corrosion fatigue crack viewed from the inside surface of condenser tubing.

Such applications as ammonia refrigeration systems and the manufacture of ammonia compounds, using Duplex Tubing of steel to the ammonia side and copper or a copper-base alloy to the water or brine side are giving excellent service. Steel withstands the ammonia while the copper, brass or bronze successfully resists the action of water or brine which would quickly corrode the steel.

Effect of Excessive Vibration. Excessive vibration accelerates corrosion and may cause corrosion-fatigue cracking of metals under certain conditions. The combined action of corrosive waters and excessive vibration of the tubing may lead to more damage than would be produced by either of these factors alone.

The pulsating impact of vapor or liquid against the tubes may cause excessive vibration of the tubing and frequently leaves evidence in the form of roughened outside surfaces. The evidence of excessive vibration can be seen sometimes as abrasion marks on the outside of the tubes where they have rubbed against each other or against the supports. Corrosion-fatigue cracking is generally recognized by small circumferential cracks varying in number from a few up to several hundred midway between the tube support sheets or a few inches from the tube sheet. Deep round pits may also develop in the same area.

Preventive Measures. Severe vibration of the tubes may exist without causing perceptible vibration of the shell. Dampening of excessive vibration can often be accomplished mechanically simply by wedging strips of wood or pieces of flattened tubing between the rows of tubes which are affected. Other measures may involve additional tube supports. In some cases, excessive vibration has been reduced by avoiding critical operating velocities of turbines, pumps, motors and similar equipment and correcting any conditions which interfere with the smooth operation of such equipment.

Laboratory Service. Corrosion research is an important function of Bridgeport's laboratory. Experience gained from years of research, field and service tests, and from working closely with operators is of much value in helping solve your tube problems.

Bridgeport manufactures many corrosion resisting condenser and heat exchanger tube alloys for use in the chemical, petro-chemical, refining and power plant fields. Duplex Tubing is supplied in such combinations as Admiralty, Muntz, Aluminum Brass, Duronze* IV (Aluminum Bronze), or Cupro Nickel on one side with steel, stainless, aluminum, monel, or nickel on the other side.

Contact the nearest Bridgeport office for service and write for the 120-page Condenser Tube Manual, containing corrosion data, suggestions for increasing tube life, information on tube alloys, methods of installing, specifications, etc.

*Reg. U. S. Pat. Off. No. 2093380

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"Bridgeport" BRIDGEPORT BRASS COMPANY
BRIDGEPORT 2, CONN. • *Established 1865*
Mills at Bridgeport, Connecticut, and Indianapolis, Indiana
In Canada—Noranda Copper and Brass Limited, Montreal

CONDENSER AND HEAT EXCHANGER TUBING

REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

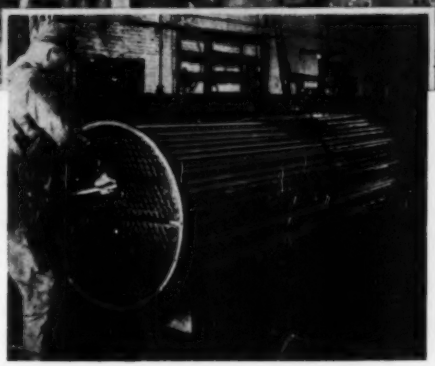
COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Southwestern Oil & Refg. Co.	Corpus Christi, Texas	Catalytic Reforming	5,000 bbls.	$800,000	.....	Completed	.....	Process Eng.	Process Eng.
Stanolind O&G Co., Opr.	Fullerton Field, Texas	Gasoline Plant	55,000 mcf	.....	Engineering	.....	.....	J & L Constr.	J & L Constr.
Stanolind O&G Co., Opr.	Slaughter, Hockley Co., Texas	Gasoline Plant	90,000 mcf	.....	Under Constr.	March, 1949	.....	Braun	Braun
Stanolind O&G Co.	Brownsville, Tex.	Chemical Plant	120,000 lbs./yr.	.....	Under Constr.	Jan. 1, 1950	.....	Badger	Badger
Stanolind O&G Co.	Pettus, Texas	Cycling Plant	160,000 mcf	.....	Under Constr.	May 1, 1949	.....	J & L Constr.	J & L Constr.
Stanolind O&G Co.	Levelland Field, Texas	Gasoline Plant	.....	.....	Planned	1950	.....	Brown & Root	Brown & Root
Stanolind O&G Co.	N. Cowden, Tex.	Gasoline Plant	75,000 mcf	.....	Engineering	1950	.....	Stearns-Roger	Stearns-Roger
Sun Oil Co.	Starr Co., Texas	Gasoline Plant	35,000 mcf	$4 million	Under Constr.	May, 1949	Pet. Eng.	Pet. Eng.	Pet. Eng.
Sun Oil Co.	Jameson Field, Coke County Texas	Gasoline Plant	10,000 mcf	Part of $12 million	Under Constr.	March, 1949	.....	Pritchard	Pritchard
*Sun Oil Co.	Sun-N. Sun Field, Texas	Gas Compression, Absorp.	.....	.....	.....	Completed	.....	.....	.....
The Texas Co.	Port Arthur, Texas	Lube & Wax Additions	†37,500 Crude †2,500 bbls. Oil	.....	Under Constr.	April 1, 1949	.....	Foster-Wheeler	Foster-Wheeler
The Texas Co.	Electra, Texas	Gasoline Plant	2,000 mcf	.....	.....	Completed	.....	Texaco	.....
The Texas Co.	Lafitte, La.	Expand Gasoline Plant	6,500 mcf	.....	.....	.....	.....	Hudson	Hudson
The Texas Co.	Port Arthur, Texas	Change to Linde, Solutiser Treating Facilities	.....	.....	Under Constr.	March 1, 1949	.....	Foster-Wheeler	Foster-Wheeler
*The Texas Co.	Ganado Field, Texas	Gas Compression	.....	.....	Under Constr.	July, 1949	.....	.....	.....
*The Texas Co.	Tijerina-Canales Field, Texas	Gas Compression	.....	.....	Under Constr.	Oct., 1949	.....	.....	.....
*The Texas Co.	Chalk-Hill Field, Texas	Gas Compression, Absorp.	.....	.....	Under Constr.	Late, 1949	.....	.....	.....
United Gas Co.	Carthage, Texas	2nd Gas Plant	100,000 mcf	$3.5 million	Under Constr.	July, 1949	.....	Hudson	Hudson
U. S. Ind. Chemicals Co.	Brownsville, Texas	Petrochemical Plant	.....	.....	Contracted	1949	.....	Badger	Badger
Waggoner Est. Ref.	Electra, Texas	Crack Unit Revisions	.....	$250,000	.....	Completed	U.O.P.	Ref. Eng.	Ref. Eng.
Warren Pet. Corp.	Hawkins, Texas	Add Plant	20,000 mcf	.....	Under Constr.	March, 1949	.....	Gaso. Plant	Gaso. Plant.
Warren Pet. Corp.	Taylor's Corner, Texas	Gasoline Plant	5,000 mcf	.....	Under Constr.	March, 1949	.....	Waleo	Waleo
Warren Pet. Corp.	Wichita Falls, Tex. (Maddox Plant)	Gasoline Plant	35,000 gals.	.....	Under Constr.	March 1, 1949	.....	Waleo	Waleo
Warren Pet. Corp.	Gladewater, Tex.	Propane Unit	30,000 gals.	.....	.....	Completed	.....	J. B. Gill Co.	J. B. Gill Co.
*Warren Pet. Corp.	Archer County, Texas	Gas Compression, Absorption	.....	.....	.....	Completed	.....	.....	.....
ROCKY MOUNTAIN									
The Carter Oil Co.	Billings, Mont.	Crude Cat. Crk.	30,000 bbls.	$20 million	Under Constr.	3rd Qtr., 1949	.....	U.O.P., S.O.D., Fluor	Fluor
Continental Oil Co.	Billings, Mont.	Complete Ref. Cat. Crack	7,500 bbls.	$6.5 million	Under Constr.	Oct., 1949	U.O.P.	U.O.P., J & L Constr.	J & L Constr.
Empire State Oil Co.	Thermopolis, Wyoming	Crude, Vacuum Units	5,000 bbls.	$325,000	Engineering Underway	May, 1949	.....	Ref. Eng.	Ref. Eng.
Gulf Oil Corp.	Eunice, N. M.	Gasoline Plant	30,000 mcf	.....	Under Constr.	Middle 1949	.....	Hudson	Hudson
New Mexico Asphalt Refg. Co.	Artesia, N. M.	Crude Unit	7,500 bbls.	$350,000	Material being Received	May, 1949	.....	Geo. Armistead	Staff
The Pure Oil Co.	Worland, Wyo.	Gasoline Plant	.....	.....	Projected	.....	.....	.....	.....
Skelly Oil Co.	Lea County, N. M.	Expanding Gasoline Plant	60,000 gals.	.....	Under Constr.	Mid 1949	.....	.....	J. E. Carlson
Socony-Vacuum	Casper, Wyo.	T C C	6,000 bbls.	.....	Under Constr.	March, 1949	.....	Staff	Cat. Constr.
Southern Union Gas Co.	Bloomfield, N. M.	Gasoline Plant	30,000 mcf	$1 million	Contracted	June, 1949	.....	Ref. Maint.	Ref. Maint.
Standard Oil (Ind.)	Casper, Wyo.	Cat. Crack	8,000 bbls.	.....	Under Constr.	Early 1949	.....	.....	Kellogg
Stanolind O&G Co.	Elk Basin, Wyo.	Gasoline Plant	12,000 mcf	.....	Under Constr.	April, 1949	.....	Stone & Webster	Stone & Webster
Texas Gulf Sulphur Co.	Worland, Wyo.	Sulfur Recovery Plant	30,000 mcf	.....	Projected	.....	.....	.....	.....
U. S. Bureau of Mines	Rifle, Colo.	Shale Oil Refy.	300 bbls.	$750,000	Under Constr.	Early 1949	.....	Ref. Eng.	Ref. Enf.
Utah Oil Refg. Co.	Salt Lake City, Utah	Propane Deasphalting	10,500 bbls.	$2.5 million	Under Constr.	Early 1949	.....	Kellogg	Kellogg
Western States Refining Co.	North Salt Lake City, Utah	New Refinery	2,500 bbls.	$350,000	.....	Completed	.....	Staff	Staff
WEST COAST									
California Asphalt Corp.	Portland, Ore.	Asphalt Packing Plant, Warehouse	.....	.....	Under Constr.	March, 1949	.....	Staff	.....
General Petroleum Corp.	Torrance, Calif.	TCC Furnace Expansion	4,000 bbls.	.....	Under Constr.	Early 1949	.....	Staff-Lummus	Lummus
Hercules Powder Co.	Hercules, Calif.	Ammonia Plant	.....	.....	Under Constr.	Summer 1949	.....	Staff	Bechtel
Mohawk Pet. Co.	Bakersfield, Calif.	Topping and Feed Preparation Unit	7,500 bbls.	$220,000	.....	Completed	None	Earle W. Gard	Key Constr.
Robt. S. Lytle, Opr	Coalinga, Calif.	H_2S Removal	33,000 mcf	$175,000	Projected	1 year	Fluor	Fluor	Fluor
Shell Chem. Corp.	Domingues, Cal.	Add Acetone	.....	.....	Under Constr.	July, 1949	.....	Braun	Braun
Shell Oil Co.	Ventura, Calif.	Gasoline Plant	.....	.....	.....	Completed	.....	Staff	Ref. Maint.
Shell Oil Co.	Wilmington, Cal.	Extend Cracking Plant Compressors	.....	.....	Under Constr.	Middle 1949	.....	Fluor	Fluor
Shell Oil Co.	Wilmington, Cal.	Extend Tank Storage	.....	.....	Under Constr.	Middle 1949	.....	Staff	Chicago Bridge & Iron Co.
Shell Oil Co.	Martinez, Calif.	Lube Handling Facilities	.....	.....	.....	Completed	.....	Staff	Staff
Standard Oil Co. of Calif.	Bakersfield, Calif.	Crude Dist.	10,000 bbls.	$7.5 million	Under Constr.	Mid 1949	Braun	Braun	Braun
Standard Oil Co. of Calif.	Bakersfield, Calif.	Thermal, Crk., Gaso. Stabil. Gaso. Treating	9,000 bbls.	.....	Under Constr.	.....	U.O.P.	U.O.P.	Braun
Standard Oil Co. of Calif.	El Segundo, Cal.	Filling Plant Modernization	.....	$2 million	Under Constr.	March, 1949	.....	.....	.....
Standard Oil Co. of Calif.	El Segundo, Cal.	Cracked Naphtha Rerun Still	22,000 bbls.	$2.6 million	Contract let	Aug., 1949	.....	Braun	Braun
Union Oil Co. of California	Oleum, Calif.	Asphalt Refined Oil Loading Facilities	.....	$457,000	Contracted	1949	.....	Early Constr.	Early Constr.
Union Oil Co. of California	Oleum, Calif.	Revision of Refining Facilities	.....	$4.2 million	Engineering	1949	.....	Parsons	Ref. Maint.

Aerial photograph of the Lawrenceville, Illinois, refinery of The Texas Company. Photo by Chicago Aerial Survey Co.

ARSENICAL ADMIRALTY TUBES

most economical in naphtha heat exchangers

... at The Texas Company Refinery



One of four 1,500 sq. ft. bundles tubed with Anaconda Arsenical Admiralty Alloy at the Lawrenceville refinery.

AT THE LAWRENCEVILLE, ILLINOIS, refinery of The Texas Company, Anaconda Arsenical Admiralty Condenser Tubes prove to be the most economical alloy in Griscom-Russell heavy naphtha exchangers on crude pipe still units. Each tube bundle, of which there are four, contains 1,500 square feet of surface. Outer surfaces of the tubes are subjected to the relatively corrosive action of straight run naphtha at about 300° F. Crude oil, which is mildly corrosive under these temperature conditions, is pumped through the tubes.

* * *

Arsenical Admiralty gets the call today in countless heat exchange applications—for one very good reason: The addition of 0.04% arsenic gives Admiralty Alloy high resistance to dezincification. This Anaconda Alloy has set outstanding performance records since its introduction on a commercial basis in 1934.

For more information on Anaconda Tubes and Plates for Condensers and Heat Exchangers, write for Publication B-2. And—feel free to consult our Technical Department on problems involving the use of metal under corrosive conditions. 48148

ANACONDA

Anaconda

HEAT EXCHANGER TUBES

THE AMERICAN BRASS COMPANY

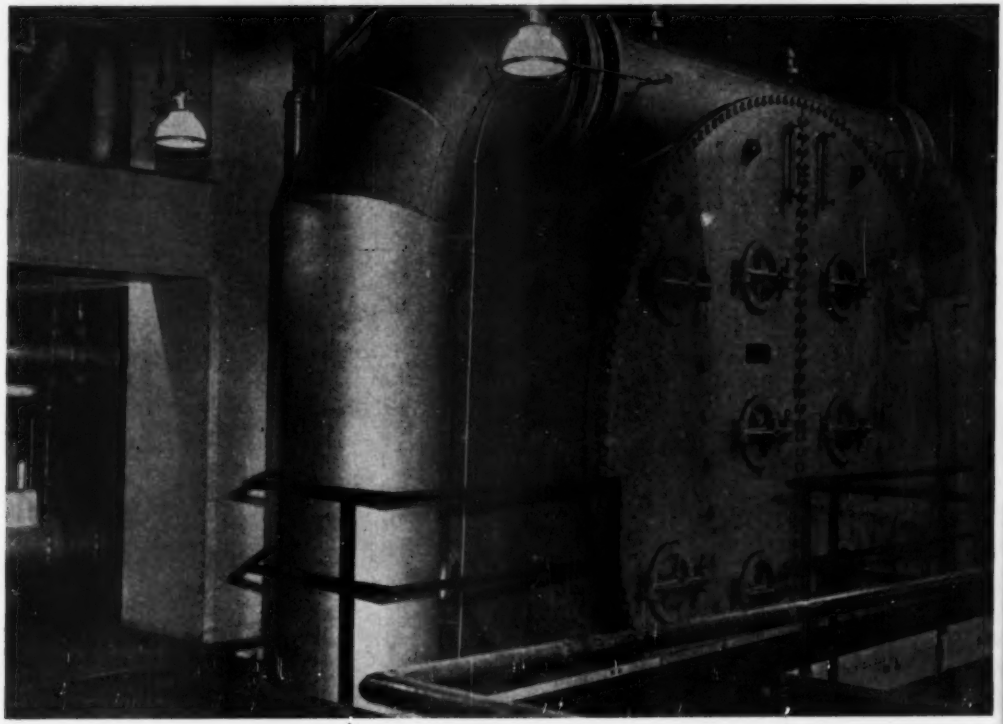
General Offices: Waterbury 88, Connecticut

Subsidiary of Anaconda Copper Mining Company

In Canada: ANACONDA AMERICAN BRASS LTD.
New Toronto, Ont.

REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Union Oil Co. of California	Oleum, Calif.	Revise Lube, Dewax Units	1,900 bbls.	$1.7 million	Contracted	1949	Union Oil Co.	Kellogg	Kellogg
Union Oil Co. of California	Oleum, Calif.	Improvements to Compound & Grease Facilities	.....	$1.2 million	Engineering	1949	.....	J. M. Montgomery & Co.	.....
Union Oil Co. of California	Oleum, Calif.	Duo-Sol Unit	6,000 bbls.	$2.9 million	Contracted	1949	Max Miller	Max Miller	Max Miller
Union Oil Co. of California	Oleum, Calif.	Tankage and Utilities	.....	$2 million	Contracted	1949	.....	Ehrhart & Arthur	Ref. Maint.
Union Oil Co. of California	Wilmington, Calif.	H_2S Recovery	30,000 bbls.	$200,000	Engineering	1949	No	Ehrhart & Arthur, Inc.	.....
FOREIGN									
Agwi Pet. Corp.	Fawley, Eng.	.....	120,000 bbls.	$140 million	Projected	1952	.....	.....	.....
Anglo-Iranian Oil.	Abadan, Iran	Gas Plant	25,000 mcf	$2 million	Under Constr.	1950	.....	Badger	Badger
Anglo-Iranian Oil.	Abadan, Iran	Cat. Cracker	30,000 bbls.	.....	Under Constr.	.....	.....	Foster-Wheeler	Foster-Wheeler
Anglo-Iranian Oil.	Abadan, Iran	Lube Plant	400 bbls.	.....	Under Constr.	.....	Texaco	Badger	Badger
Anglo-Iranian Oil.	Isle of Grain, Thames and Medway Estuary, Eng.	Central Refining Unit	60,000 bbls.	$120 million	Planning	1952	Texaco (Lube Unit)	.....	.....
Anglo-Transvaal Consolidated Investment Co.	Vaal River Union, South Africa	Synthetic Gasoline and Diesel Oil Plant	.....	$50-60 million	Planned	.....	.....	.....	.....
Arabian American Oil Co.	Abqaiq, Saudi Arabia	Crude Oil Stabilizer	300,000 bbls.	$4,800,000	Under Constr.	July-Sept., 1949	.....	Staff and Fluor	Staff and Fluor
Arabian American Oil Co.	Abqaiq, Saudi Arabia	Steam Power Plant, etc.	20,000 kw	$0,400,000	Under Constr.	July-Sept., 1949	.....	Staff and Fluor	Staff and Fluor
Arabian American Oil Co.	Ras Tanura, Saudi Arabia	Add Power Generating Unit	10,000 kw	$1,750,000	Under Constr.	July-Sept., 1949	.....	Staff and Fluor	Staff and Fluor
Arabian American Oil Co.	Ras Tanura, Saudi Arabia	Refinery Additions	.....	.....	Under Constr.	1949	.....	Bechtel	Bechtel
Azienda Generale Italiana Petroli	Rome, Italy	Add to Plant	24,000 bbls.	.....	Projected	.....	.....	.....	.....
Bahrein Pet. Co, Ltd.	Bahrein Island	Expansion Program	.....	$8.3 million	Under Constr.	Oct., 1949	.....	U.O.P., Bechtel	International, Bechtel, Inc.
Bahrein Pet. Co., Ltd.	Bahrein Island	Crude Still, Utilities	55,000 bbls.	$9.1 million	Planned	June, 1950	.....	Lummus, Bechtel	.....
Bataafsche Petroleum Maatschappij	Rotterdam-Pernis, Holland	Dewaxing Unit	60,000 bbls.	.....	.....	.....	Texaco (Dewax)	.....	.....
British-American Oil Co., Ltd.	Montreal East P. Q., Canada	Cat Cracking and Cat Poly	13,300 bbls.	.....	Under Constr.	Late 1949	Kellogg-U.O.P.	Kellogg	Kellogg
British Pet. Chem. Ltd.	Grangemouth, Scotland	Petro-Chem	.....	$20 million	Planned	.....	.....	S. & W. Badger	S. & W. Badger
Burmah Oil Co.	Burma	Furfural Plant	1,000 bbls.	$600,000	Designing	.....	Texaco	Badger	.....
Burmah Oil Co.	Syriam, Burma	Thermafor Clay Revivification	66 tons	$150,000	Design	1949	Max Miller, Socony-Vacuum	Max Miller	.....
California-Texas Co., Ltd.	Cartagena, Spain	Refinery	15,000-30,000 bbls.	.....	Proposed	March, 1951	.....	.....	.....
Caltex Pet. Maatschappij, N. V.	Rotterdam, Holland	Complete	20,000 bbls.	$18 million	Under Constr.	Early 1950	.....	McKee, Badger, U.O.P.	McKee
Cie. de Raffinage Shell-Berre	Berre, France	Capacity Increase	47,000 bbls.	.....	Planned	.....	.....	.....	.....
Cie. Française de Raffinage	Gonfreville, France	Lube Unit	2,500 bbls.	.....	Projected	.....	.....	.....	.....
Cie. Française de Raffinage	Gonfreville, France	Capacity Increase	20,000 bbls.	.....	Under Constr.	.....	.....	.....	.....
Cie. Française de Raffinage	Provence, France	Distillation Unit	20,000 bbls.	.....	.....	1950	.....	.....	.....
Cie Française de Raffinage	Provence, France	Lube Oil Unit	2,500 bbls.	.....	.....	1950	.....	.....	.....
Cie. Industrielle des Petroles	Frontignan, France	Capacity Increase	12,500 bbls.	.....	Under Constr.	.....	.....	.....	.....
Cie. de Raffinage Shell-Berre	Petit Couronne, France	Lube Unit	.....	.....	Planned	.....	.....	.....	.....
Compania Espanola de Petróleos S.A. (C.E.P. S.A.)	Canary Islands, Spain	Lube, Wax Facilities	5,000 bbls.	$45½ million	Under Constr.	Early 1950	Texaco, Standard, N. J.	Foster Wheeler	Foster-Wheeler
Conselho National da Petroleo	Santos, Brazil	Complete Refinery	20,000 bbls.	$30 million	Projected	.....	.....	.....	.....
Consolidated Ref. Ltd.	Haifa, Palestine	Crude Plant	80,000 bbls.	.....	Planned	By 1950	.....	Badger	Badger
Consolidated Ref. Ltd.	Haifa, Palestine	General Facilities	.....	.....	Under Design	.....	.....	Badger, Ltd.	.....
Consolidated Ref. Ltd.	Haifa, Palestine	Lube Plant	2,500 bbls.	.....	Designing	.....	Texaco, Juik	Lummus, Kellogg	Lummus, Kellogg
Creole Pet. Corp.	Amuay Bay, Venezuela	Hydroformer	60,000 bbls.	$70 million	Under Constr.	1951	.....	S. O. Devel. Co.	Foster-Wheeler, J. G. White
Creole Pet. Corp.	Mulata Field, Venezuela	Stabilization and Repressuring Plants	20,000 bbls. oil 60,000 mcf gas	$4.2 million	.....	Completed	.....	Braun	Braun
Creole Pet. Corp.	El Roble Field Venezuela	Repressuring	.....	.....	Planning	.....	.....	.....	.....
Egyptian Government	Cairo, Egypt	Crude Plant	.....	.....	.....	.....	.....	Lummus	Lummus
*Hi-Way Refineries, Ltd.	Saskatoon, Saskatchewan	Crude Topping Unit	2,000 bbls.	.....	Under Constr.	.....	.....	Ref. Eng.	Ref. Eng.
*Hi-Way Refineries, Ltd.	Saskatoon, Saskatchewan	Thermal Cracking Unit	500 bbls.	.....	Under Constr.	.....	.....	Ref. Eng.	Ref. Eng.
Imperial Oil, Ltd.	Edmonton, Canada	Thermal, Crack Crude Dist.	6,000 bbls.	$8.7 million	.....	Completed	.....	Barnes, Imp. Oil	Barnes
Imperial Oil, Ltd.	Edmonton, Canada	Incresse Capacity	11,000 bbls.	$2½ million	Under Constr.	Sept., 1949	.....	Staff, Barnes	Barnes
Imperial Oil, Ltd.	Ledue Field, Canada	Gas Absorption	.....	$1.5 million	Projected	.....	.....	.....	.....
Industrie Chimiche Italiane Petroli	Mantua, Italy	Crude	4,500 bbls.	.....	.....	.....	.....	.....	.....
Kuwait Oil Co.	Kuwait	Topping Unit	20,000 bbls.	$2 million	Under Constr. "Paper stage"	.....	.....	Badger	Badger
Mediterranean Ref. Co.	Trans-Arabian P.L. Mediterranean Term.	Refinery	.....	.....	.....	.....	.....	.....	.....
Mene Grande Oil Co.	West Guara, Venezuela	Repressuring	.....	.....	.....	.....	.....	.....	.....
National Oil Refineries, Ltd.	Llandarcy, Wales	Crude and Reform.	40,000 bbls.	$36 million	Designing	.....	.....	Badger	Badger
National Oil Refineries, Ltd.	Llandarcy, Wales	Lubes & Wax	1,200 bbls.			.....	Texaco	Badger	Badger



How's this for Condenser Performance?

Lummus unit serves Ohio Edison for 5 years without down-time. Oxygen content of condensate tests "zero" daily, despite wide load variation.

This surface condenser is part of a Lummus heat exchanger system installed early in 1944 in the Gorge Power Station of the Ohio Edison Company, Akron.

The unit has a deaerating-type hotwell of Lummus design. Deaeration has been constant, over loads varying from 25% to a normal maximum of 45,000 kw. The condensate has been tested every shift for oxygen content. Throughout the five-year run, the readings have fallen consistently within what our customer's engineers consider "zero"—a maximum of .005 cc per liter!

No overhauling requiring a shutdown has been necessary during this period.

For heat exchanger equipment that will perform as you want it to – with minimum maintenance – see that the job goes to Lummus. Complete information is available from our nearest office.

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Heat Exchanger Division
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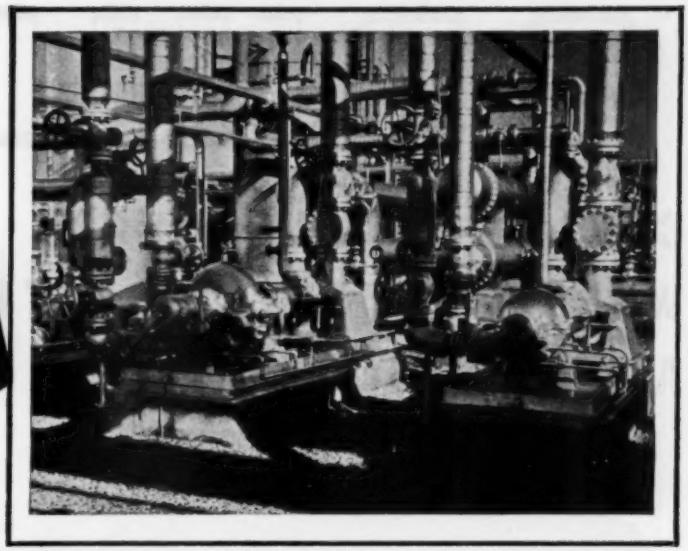
REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
National Oil Refineries, Ltd.	Llandarcy, Wales	SO_2 Solvent Extraction	3,000 bbls.	.....	Contracted	.....	.....	H. W. P.	.....
Pechelbronn S. A. E. M.	Merkwiller, France	Capacity Increase	1,580 bbls.	.....	Authorized	1950	.....	.....	.....
Petro Carbon, Ltd.	Partington, England	Cat. Cracker Lube & Reform	20,000 bbls.	.....	.....	.....	.....	.....	.....
Petro Chem., Ltd.	Partington, England	Petro Chemicals	.....	.....	.....	.....	.....	.....	.....
Petróleos Mexicano	Ciudad Madero, Mexico	Crude Unit	25,000 bbls.	$2 million	.....	Completed	None	Staff	Staff
Petróleos Mexicano	Poza Rica, Mex.	Gas Purification, Pressure Maintenance, etc.	.....	$13 million	Contracted	Early 1950	.....	McKee	McKee
Petróleos Mexicanos	Salamanca, Mex.	Crude, Gasoil, Cracking	30,000 bbls.	$12 million	Under Constr.	Early 1950	U.O.P.	McKee	McKee
Philblack, Ltd.	Avonmouth, England	Carbon Black Plant	50 million lbs. Yearly	$5 million	Contracted	1950	Phillips	H. W. P.	H. W. P.
Porto Marghera Rfg	Venice, Italy	Enlarging Crude Unit	.....	.....	Contracted	.....	.....	H. W. P.	H. W. P.
Raffineries de Pétrole de la Gironde	Ambes, France	Refinery	13,000 bbls.	$7.8 million	Under Constr.	Early 1950	.....	U.O.P., McKee	McKee
Raffineries Françaises de Pétrole de l'Atlantique	St. Nazaire, France	Consolidate Refineries	7,100 bbls.	.....	.....	.....	.....	.....	.....
Raffineries di Napoli, S. p. A.	Naples, Italy	Topping Unit	10,000 bbls.	.....	Under Constr.	Early 1949	.....	Staff	Staff
Raffineries de la Vacuum Oil Co.	Notre Dame de Gravenchon, France	Contact Plant	.....	.....	Under Constr.	Mid 1949	.....	Staff	Sta
Olii Minerali: Raffineries di Napoli, S. p. A.	Naples, Italy	Furfural Unit	1,000 bbls.	.....	Under Constr.	Early 1950	Texaco	Staff	Staff
Raffineries de la Vacuum Oil Co.	Notre Dame de Gravenchon, France	MEK Unit	1,000 bbls.	.....	Design	Early 1950	Texaco	Lummus	Staff
Raffineries de la Vacuum Oil Co.	Notre Dame de Gravenchon, France	Deasphalting Unit	1,100 bbls.	.....	Design	Mid 1950	Tulk	Lummus	Staff
Raffineries de la Vacuum Oil Co.	Notre Dame de Gravenchon, France	Furfural Unit	1,000 bbls.	.....	Under Constr.	Early 1949	Texaco	Staff	Staff
Raffineries de la Vacuum Oil Co.	Notre Dame de Gravenchon, France	Grease and Compounding Plant	.....	.....	Under Constr.	Early 1950	.....	Staff	Staff
Régie Autônome des Petroles	Bousscns, France	Absorption Plant	42,000 mcf	$2 million	Under Constr.	Early 1949	.....	Hudson	Etablissements
Scottish Oil, Ltd.	Grangemouth, Scotland	Crude	28,000 bbls.	$33 million	Designing	.....	.....	.....	Schneider
Scottish Oils, Ltd.	Grangemouth, Scotland	Cat. Crk.	5,000 bbls.		Planned	.....	.....	.....	.....
Shell Chem. Corp.	Thornton, Eng.	Petro-chem	.....	Several millions	Under Constr.	.....	.....	.....	.....
Shell Chem. Corp.	Shell Haven, England	Petro-chem	.....	.....	.....	.....	.....	.....	.....
Shell Chem. Corp.	Stanlow, Eng.	Petro-chem	.....	.....	.....	.....	.....	.....	.....
Shell Oil Co. of British Columbia	Shellburn Ref., Vancouver	Add Crude Distillation	7,500 bbls.	$600,000	Under Constr.	March, 1949	.....	Staff	Staff
Shell Oil Co. (Venezuela)	Puerto Cardon, Venezuela	Complete Refg.	.....	.....	Under Constr.	.....	.....	Lummus	Lummus
Shell Oil Co.	Heysham, Eng.	Remodel & Redesign Crude Plant	30,000 bbls.	.....	Under Constr.	Mid 1949	.....	.....	.....
Société Generale des Huiles de Pétrole	L'Avera, France	LPG and Gas Stabilising Units	.....	.....	Under Constr.	.....	.....	.....	.....
Société Generale des Huiles de Pétrole	Dunkirk, France	Crude Reform.	33,000 bbls.	.....	Designing	.....	.....	.....	.....
Société Generale des Huiles de Pétrole	Dunkirk, France	Lube & Wax	6,700 bbls.	.....	Designing	1950	Texaco	.....	.....
*Societe Industriel Belgique de Petrole	Antwerp, Beagium	Crude, Cracking Reforming	30,000 bbls.	.....	Designing	Mid., 1951	.....	.....	.....
*Societa per Azioni Raffineria Padana	San Matrino di Trecate, Italy	Refinery	13,000 bbls.	.....	Proposed	.....	.....	.....	.....
Standard Francaises des Pétroles	Port Jerome, France	Capacity Increase	30,000 bbls.	.....	Authorized	.....	.....	.....	.....
Standard Francaises des Pétroles	Port Jerome, France	Dewaxing Plant	1,000 bbls.	.....	Planned	.....	.....	.....	.....
Standard Francaises des Pétroles	Port Jerome, France	Deasphalting Plant	2,000 bbls.	.....	Planned	.....	.....	.....	.....
Stora Kopparberg	Sweden	Crude, Ther. Cracking	.....	.....	.....	.....	.....	Lummus	Lummus
Trust Oil Prod. Development Co.	North Shields, England	Crude Plant	11,500 bbls.	$4 to $8 million	Plans approved	.....	.....	.....	.....
Venezuelan Pet. Co. (Sinclair)	Puerto la Cruz, Venezuela	Refinery	35,000 bbls.	.....	Clearing site	.....	.....	.....	.....
Yacimientos Petroliferos Fiscales	La Plata Argentina	Crude Topping, Gaso Treating	30,000 bbls.	$2.8 million	Under Constr.	Early 1949	.....	Houdry Process Cat. Constr.	Cat. Constr.
Yacimientos Petroliferos Fiscales Bolivianos	Sucre, Bolivia	Crude Plant	3,000 bbls.	.....	.....	2nd Qtr., 1949	.....	Foster-Wheeler	Foster-Wheeler
YPF Bolivianos	Cochabamba, Bolivia	Topping & Reforming Units	5,000 bbls.	.....	.....	1st Qtr., 1950	.....	Foster-Wheeler	Foster-Wheeler

* First appearance in tabulation. † Added capacity.

NOTE—Badger—E. B. Badger and Sons. Barnes—W. M. Barnes & Co. Bechtel—Bechtel Corp. Bellows—W. S. Bellows Co. Braun—C. F. Braun Co. Cat. Constr.—Catalytic Construction Co. Chem. Constr.—Chemical Construction Co. Clark's—Clark's Construction and Engineering Co. Dresser—Dresser Engineering Corp. Fish Eng.—Fish Engineering Corp. Fluor—Fluor Corp. Gaso. Plant—Gasoline Plant Construction Co. General American—General American Transportation Co. Houdry—Houdry Corp. Hudson—Hudson Engineering Corp. H. W. P.—Head Wrightson Processes, Ltd. Hydro Rac.—Hydrocarbon Research, Inc. Ind. Eng.—Industrial Engineers, Inc. J & L Constr.—Construction Division, Jones & Laughlin Supply Co. Kellogg—M. W. Kellogg Co. Koch Eng.—Koch Engineering Co. Koppers—Koppers Co., Inc. Leonard—Leonard Construction Co. Lummus—The Lummus Co. Mason—Mason Brothers Construction Co. McKee—Arthur G. McKee Co. Mid-Continent—Mid-Continent Engineering Co. Max Miller—Max B. Miller & Co. Parsons—The Ralph M. Parsons Co. Pet. Eng.—Petroleum Engineering, Inc. Petro—Petroleum Rectifying Co. Pritchard—J. F. Pritchard Co. Process Eng.—Process Engineers, Inc. Ref. Eng.—Refinery Engineering Co. Ref. Maint.—Refinery Maintenance Co., Inc. S. O. D.—Standard Oil Development Co. Stearns-Roger—Stearns-Roger manufacturing Co. Tellepsen—Tellepsen Construction Co. Texaco—Texaco Development Co. U.O.P.—Universal Oil Products Co. Wales—Wales Engineering. Wohlfeld—Wohlfeld Construction Co. Equally owned by California Texas Corp. and Socony-Vacuum Oil Co., Inc.



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Manufactured under U. S. Patents No. 2,-210,808; No. 2,309,309; No. 2,338,926 and No. 2,-341,091 and other Patents Pending.

Tray illustrated is a 5'-4" diam. bubble tray made of 12% chrome, type 410 stainless steel with straight downcomer. Note the "set-on" type risers and holddown frogs. These frogs, installed from the top of deck and snapped in the riser openings, eliminate the need for a man under the deck when installing or removing caps and risers.

WHY? Because in usual operation coke has very little affinity for GLITSCH alloy trays and caps.

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Any accumulation of sludgy sediment that might tend to collect is easily removed with a hose. GLITSCH light weight trays and caps are removable — with a minimum of manpower — and it isn't necessary to disturb the supporting trusses. (And it's much safer for the men to handle the light weight trays)

MANUFACTURED UNDER U. S. PATENT NO. 2,210,808; NO. 2,309,309; NO. 2,338,926; NO. 2,341,091 AND OTHER PATENTS PENDING

Glitsch

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"TRUSS-TYPE" BUBBLE TRAYS ● BUBBLE CAPS ● TOWER INTERNALS

Field Stress Relief Of Vessels by Radiant Electric Heating

***THE FIELD** stress relief of heavy-walled pressure vessels sometimes constitutes a major problem for plant engineering and construction groups. Various means for heating vessels with flue gases, with induction coils, and so on, have been the usual solution, with the method selected dependent upon the particular problem at hand and the equipment available. This present article describes an entirely new approach to the old problem. Electric radiant heating is a rather simple method for stress relieving large pressure vessels. It gives promise for wide application to the typical cases encountered in process plants. The equipment required is not extensive and is generally available in plant supply stocks and maintenance departments.*

MILTON LUDWIG
Standard Oil Company of California
San Francisco

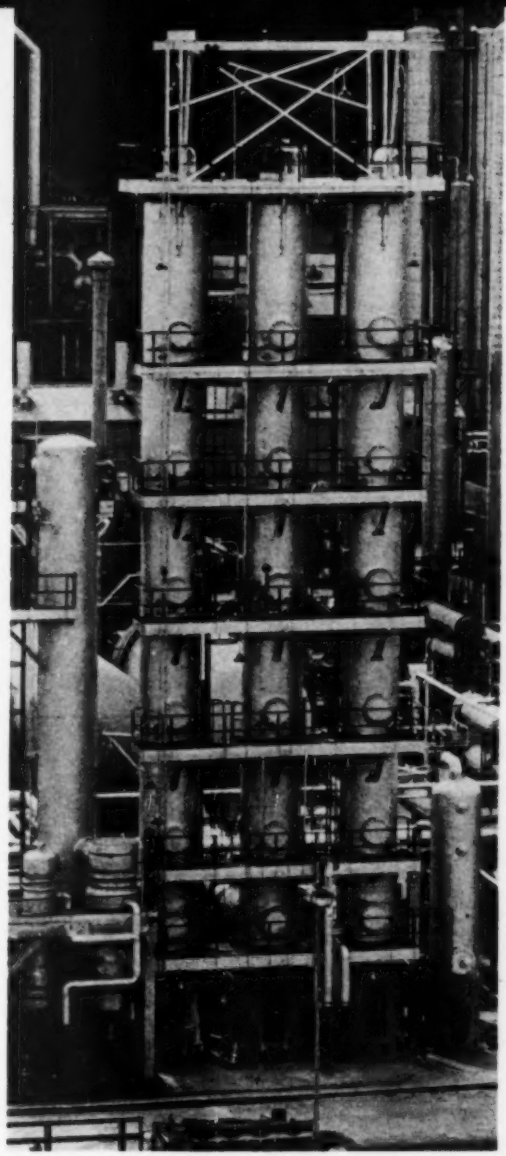


Photo of reactors (two at left) which were stress-relieved by electric heating. Two of three similar tall vessels were so treated. The third was a new unit on which no field alternations had been performed and so required no field stress relief.

IF EXTENSIVE field alterations by welding must be performed on an existing heavy-walled vessel the application of proper stress relief for the field welds presents a difficult problem. This problem recently arose in connection with two 1½-inch thick, 54-inch inside diameter by 78-foot high reactors in Standard Oil Company of California's Richmond refinery. After a study of various possible means of stress relieving these vessels it was decided that best results could be achieved by application of radiant electrical heat using a single centrally located heating element suspended from the top of the vessel. The arrangement of the electrode and location of the temperature points is shown on Figure 1.

In the past, vertical vessels have been stress relieved by heating with flue gas from a furnace located at the bottom of the column but electric heat has the advantages that heating is more uniform throughout the height of the column and that it avoids an open flame immediately adjacent to operating plants. The stress-relief operation was fully successful and it is the purpose of this article to discuss the design considerations which were involved and the details of the actual installation.

Insulation of Vessels

Any vessel that is to be stress relieved in the field by radiant electrical heat must be externally insulated to

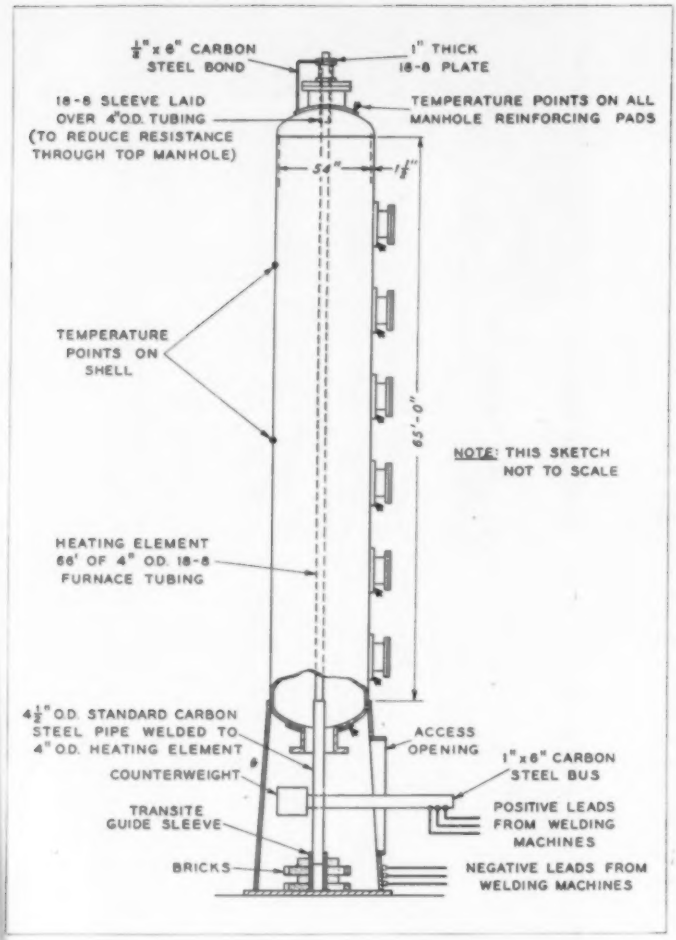

1/2" x 6" CARBON STEEL BOND
1" THICK 18-8 PLATE
18-8 SLEEVE LAID OVER 4" OD. TUBING (TO REDUCE RESISTANCE THROUGH TOP MANHOLE)
TEMPERATURE POINTS ON ALL MANHOLE REINFORCING PADS
54"
1 1/2"
TEMPERATURE POINTS ON SHELL
65'-0"
NOTE: THIS SKETCH NOT TO SCALE
HEATING ELEMENT 66' OF 4" OD. 18-8 FURNACE TUBING
4 1/2" O.D. STANDARD CARBON STEEL PIPE WELDED TO 4" O.D. HEATING ELEMENT
ACCESS OPENING
1" x 6" CARBON STEEL BUS
COUNTERWEIGHT
TRANSITE GUIDE SLEEVE
POSITIVE LEADS FROM WELDING MACHINES
BRICKS
NEGATIVE LEADS FROM WELDING MACHINES

FIGURE 1
General arrangement of heating element and temperature points.

keep the heating requirements within reasonable limits and it should be free of internal obstructions that might interfere with installation of the heating element and with radiation of heat to the interior surface of the vessel. The particular vessels to be stress relieved were free of such internal obstructions and most of the original 1½-inch thick glass fiber insulation was still in place after the vessel alterations had been completed. It was, however, necessary to do considerable patching with rock-wool blanket and plastic insulation. As a result of this patching, the insulation was in poor mechanical condition and was replaced after the stress relief operations were completed. It is also possible that the high stress relief temperatures might damage any insulation not intended for high temperature service.

Design of Heating Element

Heat loss calculations indicated that the steady-state heat loss from the vessel would be 130 kw. with the vessel at 1000° F. above ambient temperature and that 200 kw. would be required to raise the vessel temperature 1000° F. in 20 hours. Various sources of power for the electric heating were considered but it was finally decided to use a battery of direct current welding machines connected in parallel. A maximum of 28 motor-generator welding machines operated from the 440-volt 3-phase power supply were used. The direct use of 440-volt power for heating also was considered but was rejected because of safety considerations. Another advantage of the low voltage power from the welding machines was that it made possible the design of a heating element of extreme simplicity. This heating element consisted of about 66 feet of scrap 4-inch o.d. stainless steel (18-8) furnace tube with an average thickness of about 0.20 inches. The computed resistance of this tubing is 0.0145 ohms at 1500° F. for which the potential drop is 58 volts at 4000 amps. The maximum observed potential was 60 volts at 4050 amps, which corresponds to 243 kw. This is about 3.1 kw. per square foot of heating surface for which condition the computed heater temperature is 1550° F., assuming an emissivity of 0.70 with a vessel temperature of 1200° F.

The presence of 24-inch manholes through the top and bottom heads of the vessel simplified the installation of the heating element since it was only necessary to weld the heating tube to a stainless steel cover plate at the top and to pass it through the open manhole at the bottom. That part of the heating element below the bottom head-shell seam and in the column skirt was made of carbon steel 4.5-inch o.d. standard weight pipe so as not to overheat the skirt. Carbon steel has about one-tenth the resistance of 18-8 stainless steel so the heat release per foot is only one-tenth as great. A 1 by 6-inch carbon steel bus passed horizontally through the pipe about 2 feet from its lower end. A vertical clearance of 15 inches was left for downward thermal expansion of the heating element. The sides of the access opening were bricked up to prevent accidental contact between the bus and the column skirt.

Temperature Readings

Temperatures were taken every half hour at ten different points by means of thermocouples located as shown on Figure 1. The first reactor was stress relieved with extreme temperatures of 890° F. and 1160° F. during the soaking period. The temperature of 890° F. is below the minimum required stress relief temperature of 900° F. but this temperature occurred on the top head where no alteration work had been done. The temperature variation of 270° F. is in excess of the 150° F. permitted by the API-ASME code but was considered acceptable in view of the fact that the entire vessel was heated so that the uniformity of temperature was much better than could have been obtained by local stress relief of those parts of the vessel where field welding had been done. Temperatures of diametrically opposite points at the same elevation were less than

50° F. apart and the nearest points with a temperature difference as great as 150° F. were about 20 feet apart. Before the second vessel was stress relieved more careful attention was given to the insulation repairs and, as a result, the extreme temperatures during the soaking period had a minimum spread of 1040 to 1180° F. or 140° F. The temperature of several points reached a maximum of 1200° F. but the rise was stopped by opening the insulation at these points. Temperature readings for the second reactor are tabulated as Table 1.

TABLE 1
Temperature Readings

Time From Start, Hrs.	Average Temp.	Maximum Temp.	Minimum Temp.
10	607	690	520
12	718	820	620
14	813	910	710
16	895	990	780
18	962	1050	850
20	1021	1100	910
22	1074	1140	960
24	1123	1190	1000[3]
26	1139	1200	1020[2]
28	1138	1190	1030[2]
30	1134	1190	1030[2]
32	1139	1180	1040[2]
34	1135	1180	1040[2]
36	1086	1130	980
38	1029	1080	930
40	974	1030	870

REMARKS: [1] Power input reduced.
[2] Soaking period.
[3] Power input stopped at 34½ hours.

Temperature-Time Equations

As already mentioned the heat input to the column must be somewhat greater than the equilibrium heat loss in order to bring the vessel up to temperature in a reasonable length of time. The differential equation for the heating period may be written as

$$P = A \frac{dT}{d\theta} + BT$$

in which P = total power input, kw.

T = temperature difference between vessel and atmosphere, °F.

θ = time from start of heating, hours

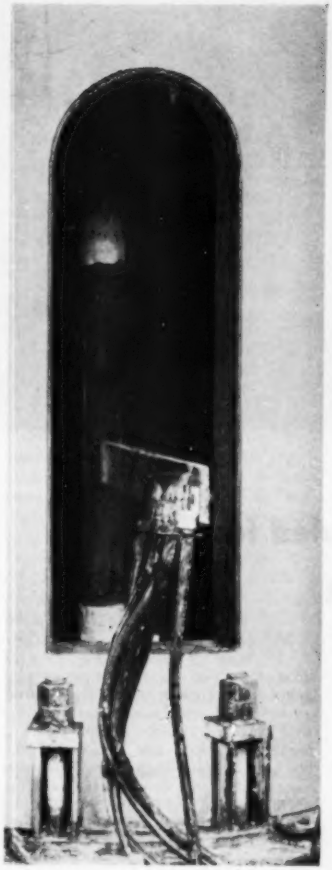
A = heat capacity of vessel, kwh. per °F.

B = heat loss through insulation, kw. per °F.

This equation may be integrated to give the time required to heat to any temperature. The result is

$$\theta = \frac{A}{B} \ln \left(\frac{1}{1 - \frac{BT}{P}} \right)$$

if heating is started when the vessel is at atmospheric temperature. Each vessel to be stress relieved had a total insulated surface of about 1100 square feet with an estimated heat loss of 0.40 Btu. per square feet per °F. Then



Electrical hookup at bottom of one of the reactors which were stress relieved.

$$B = \frac{1100 \times 0.40}{3412} = .129 \text{ kw. per °F.}$$

The computed vessel weight was 80,000 pounds and, if the heat capacity of steel is taken as 0.1075 Btu. per pound per °F.,

$$A = \frac{80{,}000 \times .1075}{3412} = 2.52 \text{ kwh. per °F.}$$

If P = 200 kw. and if heating is started with the vessel at atmospheric temperature,

θ = 20 hours to raise temperature by 1000° F.

The conductivity of insulating materials increases with temperature so that, if an average conductivity is used, the actual initial rate of temperature rise will be higher than computed and at high temperatures the rate of rise will be less than computed. This variation of insulation conductivity is helpful since the heat loss from hot spots is increased thereby tending to make the vessel temperature more uniform.

The vessels to be stress relieved were adjacent to operating plants and it therefore was necessary to take precautions to prevent a fire in case flammable vapors should be released. The welding machines were located some distance away in a less hazardous area but there still was some concern that flammable vapors might be ignited by the internal heating element. This concern was overcome by provision for injection of steam within the heated vessel in case flammable vapors should be released. If further precautions had been considered necessary, it would have been possible to keep the vessel full of steam during the entire heating period. The use of steam or any other inert gas, has the additional advantage that it will minimize internal oxidation at the high stress relief temperatures.

Possible Sources of Power

Welding machines were used as a source of power to forestall objections to the hazards of a higher voltage. The machines were available from the contractor doing other work in the refinery. In a situation where such machines were not available, or could be procured only at excessive cost, a method to utilize directly available power such as 3-phase 440-volt doubtless could be devised. A heating unit suitable for 3-phase power might consist of three separate tubes hung from the top of the column and spaced far enough apart to avoid accidental contact. The power could be fed in at the bottom with the three elements bonded together at the top to form a wye-connected load. The neutral point at the top could be grounded to the column if such grounding of the 440-volt system is permissible; otherwise, it would be necessary to insulate the heater from its supports. A 440-volt heater would require far less material than the low voltage single element heater which would be an advantage if scrap material were not available for a low voltage heater. Solid conductors probably would not be suitable since they would not provide enough surface area to release the required heat without reaching an excessive temperature.

The field work in the operation described above was carried out by Bechtel Corporation, the contractor on the job, under the direction of Standard of California engineers.

So far as is known, radiant electrical heat has not in the past been used for the field stress relief of large vessels and the author would be pleased to hear of any past or future applications of this method.

Above—Aerial view of Wasson No. 2, gasoline plant owned by Shell Oil Company, Inc., and Coltexo Corporation in West Texas. Wasson No. 1 and Denver City can be seen at the upper right corner of the picture. Areas enclosed by dotted lines indicates the approximate location of the new additions to the plant: 1) area for installation of new storage tanks; 2) new laboratory; 3) boilers; 4) absorption-distillation area; 5) cooling tower extension; 6) compressor building extension for eight new compressors; 7) new compressor building to house eight new compressors, 6400 horsepower, and 8) location of small cooling tower for engine jacket water.

Enlargement Scheduled for Wasson No. 2 Plant

WASSON No. 2, natural gasoline plant near Denver City, in West Texas, jointly owned by Shell Oil Company, Inc., and Coltexo Corporation, is scheduled for construction of new facilities that will increase its processing capacity to 96 million cubic feet daily of casinghead gas. The plant, operated by Shell, originally had 6400 compressor horsepower capacity, which was doubled recently by the addition of eight 800-h.p. engines.

Additional facilities now planned are to process casinghead gas that has been burned in flares. Of 1600 wells in the field, about 1500 have been connected to the plant and others are to be tied in. In the program is the installation of 6400 more compressor horsepower, which will bring the total to 19,200; an engine jacket-water cooling tower; a new process unit with one new absorber for a total of three absorbers (200 psig.), a de-ethanizer, still, and a depropanizer. The de-ethanizer included in the new process unit will de-ethanize the combined streams from both the old and new distillation units. Equipment of the new unit will provide 60 percent recovery of propane and substantially all of the butanes and gasoline. An existing process cooling tower has recently been enlarged by the addition of several bays, the propane and gasoline storage capacity will be substantially increased. Also planned is construction of a new laboratory, and the addition of two new boilers to supply process steam.

After construction of the new process unit, the plant will produce some 110,000 gallons per day of propane, which will be shipped in tank cars. Gasoline and butane production amounting to about 210,000 gallons per day will be transported in Shell's crude oil pipe line.

Residue gas from the plant will be utilized by Southwest Public Service Company for generation of electrical power; by Columbian Carbon Company, for production of furnace-type carbon black, and by El Paso Natural Gas Company in the Texas-California gas transmission line.

Below, left—Suction and discharge lines for the gas compressors at Wasson No. 2 are clamped to concrete piers alongside the walkway. The lines entering the compressor building from the pipe stanchions supply the engine jackets with cooling water. Right—Original compressor installation at Wasson No. 2 consisted of eight 800-horsepower engines to compress 32 million cubic feet daily.

THERMOCHEMISTRY

For the Petrochemical Industry

KENNETH A. KOBE and ERNEST G. LONG
Department of Chemical Engineering, University of Texas, Austin

Part II—Paraffinic Hydrocarbons, C_1-C_6

THIS SECOND article of the series initiated by Kenneth A. Kobe in the January issue of PETROLEUM REFINER continues the announced effort to put into useful form basic thermodynamic data needed by every technical man who has occasion to make thermodynamic calculations to any appreciable extent.

Dr. Kobe is professor of chemical engineering at the University of Texas and Mr. Long is Celanese Corporation Fellow in chemical engineering there.

THE PREVIOUS paper[18] constituted an introduction to a series in which will be presented thermodynamic data on technically important gases and vapors. The method of selection and usefulness of the data presented are discussed in detail in the introductory article and will not be further discussed here or in subsequent articles except in special cases.

This paper presents thermochemical data for the lower members of the paraffinic hydrocarbon series— methane, ethane, propane, isobutane, normal butane, normal pentane and normal hexane. In this instance, as well as with the other hydrocarbons, the *American Petroleum Institute Research Project 44*[23] has made the work considerably easier. The data recommended in this paper are in essential complete agreement with their data. Both the API 44 report and this paper have accepted the excellent work of Pitzer[21] and Pitzer and Kilpatrick[22] as being the most reliable data available. For methane, data up to 2500° K. have been included by using the data of Kelley[13] beyond 1500° K., the limit of Pitzer's calculations. In Table 1 are listed the various sources of heat capacity data for the seven compounds considered here. Table 2 tabulates the recommended data of the API 44 report for the standard heats of formation and combustion and the standard free energies of formation.

The heat capacity data are presented conveniently on all four temperature scales in Tables 3, 4, 5 and 6. These data are tabulated at integral hundred degree increments and also at the useful 0.18 and 25° C. and 32, 60 and 77° F. points. In Figure 1 are plotted the heat capacity-temperature curves on the Centigrade and Fahrenheit temperature scales.

Tables 7, 8, 9 and 10 are tabula-

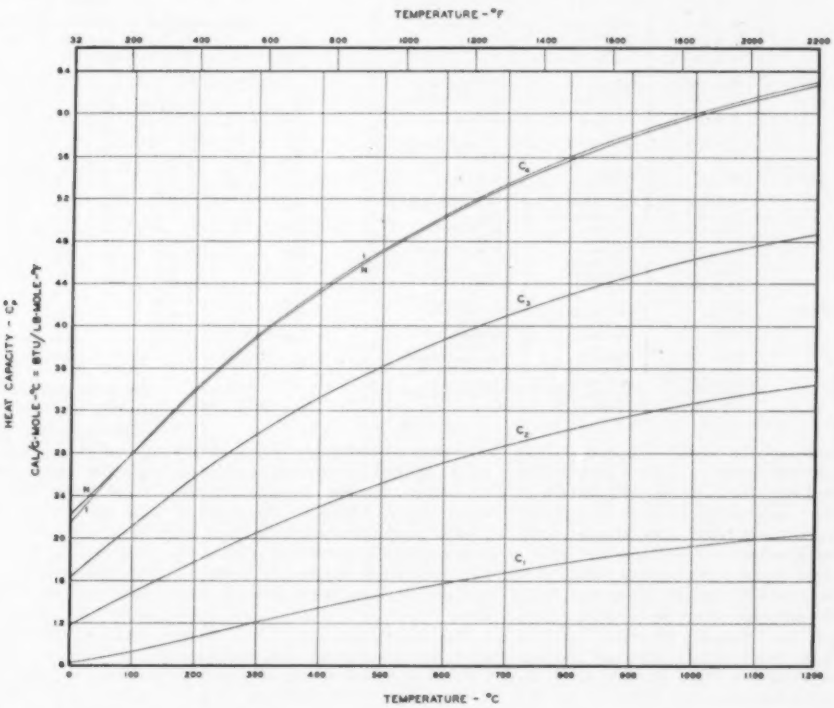


FIGURE 1
Heat Capacity Curves for Methane, Ethane, Propane, n-Butane and Iso-Butane.

TABLE 1

Reported heat capacity data for paraffinic hydrocarbons.

Compound	Temp. Range	Method	Workers	Ref.
Methane	−80 to +15° C.	Calorimetric	Henne	11
	142 to 778° K.	Calorimetric	Millar	19
	0 to 220° C.	Calorimetric	Eucken and Lude	7
	410° K.	Calorimetric	Bennewitz and Rossner	2
	20 to 300° C.	"Molecular Beam"	Beeck	1
	250 to 1500° K.	Spectroscopic	Stull and Mayfield	26
	0 to 500° C.	Spectroscopic	Vohl	30
	300 to 2500° K.	Spectroscopic	Kelley	13
	0 to 1000° C.	Spectroscopic	Justi	12
	291 to 1500° K.	Spectroscopic	Thompson	29
	−71 to 2750° C.	Spectroscopic	Ellenwood, Kulik and Gay	6
	298 to 1500° K.	Spectroscopic	Pitzer	21
	273 to 1500° K.	Compilation	API 44	23
Ethane	−82 to +15° C.	Calorimetric	Henne	11
	143 to 280° K.	Calorimetric	Eucken and Weigert	10
	188 to 374° K.	Calorimetric	Eucken and Parts	8
	2 to 64° C.	Calorimetric	Thayer and Stegeman	28
	143 and 163° K.	Hot-wire	Kistiakowsky and Nazmi	16
	93 to 334° K.	Calorimetric	Kistiakowsky, Lacher and Stitt	15
	410° K.	Calorimetric	Bennewitz and Rossner	2
	272 to 365° K.	Calorimetric	Kistiakowsky and Rice	17
	74 to 330° C.	Calorimetric	Dailey and Felsing	4
	20 to 300° C.	"Molecular Beam"	Beeck	1
	250 to 1500° K.	Spectroscopic	Stull and Mayfield	26
	291 to 1500° K.	Spectorscopic	Thompson	29
	298 to 1500° K.	Spectroscopic	Pitzer	21
	298 to 1000° K.	Spectroscopic	Brickwedde, Moscow and Aston	3
	273 to 1500° K.	Compilation	API 44	23
Propane	70 to 340° F.	Calorimetric	Sage, Webster and Lacey	25
	74 to 330° C.	Calorimetric	Dailey and Felsing	4
	176° F.	Calorimetric	Sage and Lacey	24
	272 to 365° K.	Calorimetric	Kistiakowsky and Rice	17
	148 to 259° K.	Calorimetric	Kistiakowsky, Lacher and Ransom	14
	20 to 300° C.	"Molecular Beam"	Beeck	1
	250 to 1500° K.	Spectroscopic	Stull and Mayfield	26
	298 to 1500° K.	Spectroscopic	Pitzer	21
	273 to 1500° K.	Compilation	API 44	23
n-Butane	60 to 220° F.	Calorimetric	Sage and Lacey	14
	345 to 693° K.	Calorimetric	Dailey and Felsing	5
	25° C.	Calorimetric	Templeton, Davies and Felsing	27
	70 to 280° F.	Calorimetric	Sage, Webster and Lacey	25
	250 to 1500° K.	Spectroscopic	Stull and Mayfield	26
	298 to 1500° K.	Spectroscopic	Pitzer	21
	298 to 1500° K.	Spectroscopic	Pitzer and Kilpatrick	22
	298 to 1500° K.	Compilation	API 44	23
so-Butane	348 to 693° K.	Calorimetric	Dailey and Felsing	5
	243 to 353° K.	Calorimetric	Wacker, Cheney and Scott	31
	70 to 340° F.	Calorimetric	Sage, Webster and Lacey	25
	298 to 1500° K.	Spectroscopic	Pitzer and Kilpatrick	22
	273 to 1500° K.	Compilation	API 44	23
n-Pentane	410° K.	Calorimetric	Bennewitz and Rossner	2
	183 and 321° C.	Calorimetric	Eucken and Sarstedt	9
	331 to 427° K.	Calorimetric	Pitzer	20
	130 to 310° F.	Calorimetric	Sage, Webster and Lacey	25
	250 to 1500° K.	Spectroscopic	Stull and Mayfield	26
	298 to 1500° K.	Spectroscopic	Pitzer	21
	298 to 1500° K.	Spectroscopic	Pitzer and Kilpatrick	22
	273 to 1500° K.	Compilation	API 44	23
n-Hexane	410° K.	Calorimetric	Bennewitz and Rossner	2
	334 to 469° K.	Calorimetric	Waddington and Douglin	32
	178 to 301° C.	Calorimetric	Eucken and Sarstedt	9
	250 to 1500° K.	Spectroscopic	Stull and Mayfield	26
	298 to 1500° K.	Spectroscopic	Pitzer	21
	298 to 1500° K.	Spectroscopic	Pitzer and Kilpatrick	22
	298 to 1500° K.	Compilation	API 44	23

TABLE 2

Free energy of formation, heat of formation and heat of combustion paraffinic hydrocarbons, C_1-C_6, at 25° C.[1]

	Molecular Weight	$\Delta G°_f$ cal./g-mole	$\Delta H°_f$ cal./g-mole	$-\Delta H°_c$ cal./g-mole	
				H_2O (liq.) CO_2(gas)	H_2O(gas) CO_2(gas)
Methane	16.042	−12,140	−17,889	212,798	191,759
Ethane	30.068	− 7,860	−20,236	372,820	341,261
Propane	44.094	− 5,614	−24,820	530,605	488,527
n-Butane	58.120	− 3,754	−29,812	687,982	635,384
iso-Butane	58.120	− 4,296	−31,452	686,342	633,744
n-Pentane	72.146	− 1,960	−35,000	845,160	782,040
n-Hexane	86.172	+ 50	−39,960	1,002,570	928,930

[1] $-\Delta H°_c$ represents the heat evolved at 25° C. and constant pressure in the combustion of the gaseous hydrocarbon in gaseous oxygen to form the products indicated with all the reactants and products in their appropriate standard reference states.

$\Delta H°_f$ and $\Delta G°_f$ represents the change in the heat content (enthalpy) and free energy, respectively, for the formation of the gaseous hydrocarbons from the elements, with all the reactants and products in their appropriate standard reference states.

TABLE 3

Heat capacities of paraffinic hydrocarbons, C_1-C_6. cal./g-mole • °C.

°C.	C_1	C_2	C_3	n-C_4	i-C_4	n-C_5	n-C_6
0	8.295	11.856	16.32	22.17	21.41	27.57	33.05
18	8.460	12.372	17.26	23.23	22.63	28.87	34.54
25	8.536	12.585	17.57	23.61	23.14	29.30	35.06
100	9.389	14.86	21.26	28.19	28.08	34.93	41.70
200	10.748	17.88	25.88	34.06	34.13	42.15	50.24
300	12.171	20.66	29.90	39.18	39.36	48.38	57.61
400	13.53	23.11	33.26	43.54	43.78	53.68	63.84
500	14.78	25.29	36.35	47.30	47.57	58.25	69.20
600	15.92	27.21	38.96	50.61	50.84	62.23	73.86
700	16.96	28.90	41.27	53.47	53.70	65.73	77.90
800	17.87	30.40	43.26	55.97	56.20	68.76	81.43
900	18.67	31.69	44.98	58.18	58.35	71.35	84.53
1000	19.39	32.83	46.52	60.10	60.27	73.66	87.31
1100	20.02	33.83	47.84	61.72	61.90	75.68	89.84
1200	20.58	34.70	48.99	63.18	63.29	77.34	91.51
1300	21.06	....	....	....	....	....	....
1500	21.86	....	....	....	....	....	....
1700	22.50	....	....	....	....	....	....
2000	23.11	....	....	....	....	....	....
2200	23.54	....	....	....	....	....	....

TABLE 4

Heat capacities of paraffinic hydrocarbons, C_1-C_6 cal./g-mole. • °K

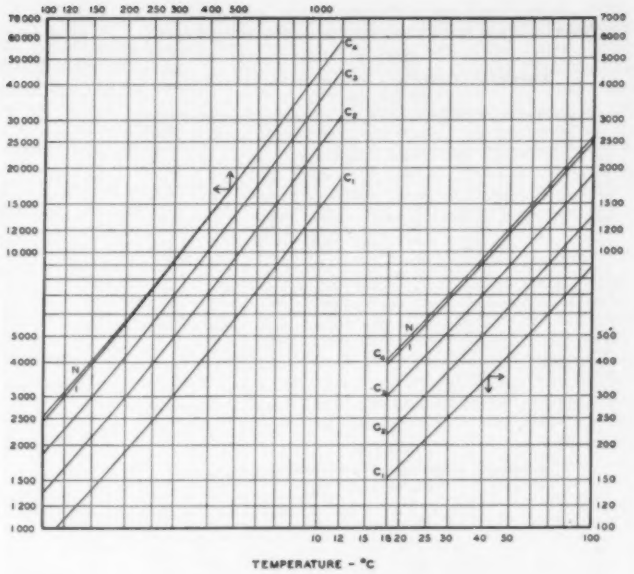
°K.	C_1	C_2	C_3	n-C_4	i-C_4	n-C_5	n-C_6
273	8.295	11.856	16.32	22.17	21.41	27.57	33.05
291	8.460	12.372	17.26	23.23	22.63	28.87	34.54
298	8.536	12.585	17.57	23.61	23.14	29.30	35.06
300	8.552	12.648	17.66	23.77	23.25	29.51	35.32
400	9.736	15.68	22.54	29.80	29.77	36.91	44.04
500	11.133	18.66	27.04	35.54	35.62	43.96	52.39
600	12.546	21.35	30.88	40.42	40.62	49.88	59.38
700	13.88	23.72	34.20	44.61	44.85	54.98	65.35
800	15.10	25.83	37.08	48.23	48.49	59.37	70.51
900	16.21	27.69	39.61	51.42	51.65	63.21	75.01
1000	17.21	29.33	41.83	54.20	54.40	66.57	78.94
1100	18.09	30.77	43.75	56.60	56.81	69.46	82.32
1200	18.88	32.02	45.42	58.72	58.89	72.01	85.30
1300	19.57	33.11	46.89	60.55	60.71	74.22	87.89
1400	20.18	34.07	48.16	62.15	62.29	76.14	90.12
1500	20.71	34.90	49.26	63.51	63.67	77.76	92.02
1600	21.19	....	....	....	....	....	....
1800	21.97	....	....	....	....	....	....
2000	22.59	....	....	....	....	....	....
2200	23.01	....	....	....	....	....	....
2500	23.61	....	....	....	....	....	....

tions of the molal enthalpies (heat contents) relative to the ice-point. The enthalpy data of the API 44 report were not used because their enthalpy values are relative to absolute zero temperature and in order to convert them to ice-point relative values it is necessary to subtract from each value the enthalpy at the ice-point. For temperatures near the ice-point, the result is a small number obtained by subtracting one large number from another large number. Although the API 44 values are accurate, small differences obtained by subtracting consecutive values are not. Accordingly, the values reported here are the result of careful integration above 0° C. of the heat capacity-temperature relation of each compound. Figure 2 is a convenient double logarithmic plot of these data.

The mean heat capacities above 0° C. are reported on Centigrade and Fahrenheit scales in Tables 11 and 12. As explained in the previous paper,[18] the mean heat capacities of Tables 11 and 12 are mathematically equivalent to the enthalpy data reported in Tables 7 and 9, respectively. The equations for the heat capacities of the gases tabulated in Table 13 were derived by the method previously explained.[18] These equations, equivalent on all four temperature scales, were derived for the temperature ranges 0-1200° C., 273-1500° K., 32-2200° F. and 492-2600° R. In only one case (methane) was the maximum error encountered greater than 1 percent. The average maximum error for the seven compounds is 0.7 percent. The largest aver-

FIGURE 2

Relative Enthalpies for Methane, Ethane, Propane, n-butane, and iso-butane. Multiply reading in P.C.U./lb.-mole by 1.8 to find Btu/lb.-mole.



age error (also methane) is 0.6 percent—the average of the seven being 0.23 percent.

LITERATURE CITED

[1] Beeck, O., J. Chem. Phys., **4**, 680 (1936).
[2] Bennewitz, K., and Rossner, W., Z. physik. Chem., **B39**, 126 (1938).
[3] Brickwedde, F. G., Moscow, M., and Aston, J. C., J. Research Natl. Bur. Standards, **37**, 263 (1946); Research paper RP1747.
[4] Dailey, B. P., and Felsing, W. A., J. Am. Chem. Soc., **65**, 42 (1943).
[5] Dailey, B. P., and Felsing, W. A., Ibid., **65**, 44 (1943).
[6] Ellenwood, F. O., Kulik, N., and Gay, N. R., Cornell Univ. Expt. Station, Bull. **30**, 4 (October, 1942).
[7] Eucken, A., and Lude, K., Z. physik. Chem., **B5**, 413 (1929).
[8] Eucken, A., and Parts, A., Ibid., **B20**, 184 (1933).
[9] Eucken, A., and Sarstedt, B., Ibid., **B50**, 143 (1941).
[10] Eucken, A., and Weigert, K., Ibid., **B23**, 265 (1933).
[11] Heuse, W., Ann. Phys., **59**, 86 (1919).
[12] Justi, E., *Specific Heat, Enthalpy, Entropy and Dissociations of Technical Gases*, p. 149, Berlin, Julius Springer (1938); photo-lithoprint reproduction by Edwards Bros., Ann Arbor, Mich. (1944).
[13] Kelley, K. K., U. S. Bur. Mines, Bull. **407**, 2 (1937).
[14] Kistiakowsky, G. B., Lacher, J. R., and Ransom, W. W., J. Chem. Phys., **8**, 970 (1940).
[15] Kistiakowsky, G. B., Lacher, J. R., and Stitt, F., Ibid, **7**, 289 (1939).
[16] Kistiakowsky, G. B., and Nazmi, F., Ibid., **6**, 18 (1938).
[17] Kistiakowsky, G. B., and Rice, W. W., Ibid., **7**, 281 (1939).
[18] Kobe, K. A., Petroleum Refiner, **28**, 83 (Jan., 1949).
[19] Millar, R. W., J. Am. Chem. Soc., **45**, 874 (1923).
[20] Pitzer, K. S., Ibid., **63**, 2413 (1941).
[21] Pitzer, K. S., Ind. Eng. Chem., **36**, 829 (1944).
[22] Pitzer, K. S., and Kilpatrick, J. E., Chem. Rev., **39**, 435 (1946).
[23] Rossini, F. D., et al, "Selected Values of Properties of Hydrocarbons," U. S. Natl. Bur. Standards, Circ. **C461** (1948); American Petroleum Institute Research Project 44.
[24] Sage, B. H., and Lacey, W. N., Ind. Eng. Chem., **27**, 1484 (1935).
[25] Sage, B. H., Webster, D. C., and Lacey, W. N., Ibid., **29**, 1309 (1937).
[26] Stull, D. R., and Mayfield, F. D., Ibid., **35**, 639 (1943).
[27] Templeton, D. H., Davies, D. D., and Felsing, W. A., J. Am. Chem. Soc., **66**, 2033 (1944).
[28] Thayer, V. R., and Stegeman, G., J. Phys. Chem., **35**, 1505 (1931).
[29] Thompson, H. W., Trans. Faraday Soc., **37**, 344 (1941).
[30] Vold, R. D., J. Am. Chem. Soc., **57**, 1192 (1935).
[31] Wacker, P. F., Cheney, R. K., and Scott, R. B., J. Research Natl. Bur. Standards, **38**, 651 (1947); Research paper RP1804.
[32] Waddington, G., and Douslin, D. R., J. Am. Chem. Soc., **69**, 2275 (1947).

TABLE 5

Heat capacities of paraffinic hydrocarbons, C_1-C_6
Btu/lb.-mole ° °F.

°F.	C_1	C_2	C_3	n-C_4	i-C_4	n-C_5	n-C_6
32	8.295	11.856	16.32	22.16	21.41	27.57	33.05
60	8.439	12.304	17.10	23.08	22.46	28.89	34.35
77	8.536	12.585	17.57	23.60	23.14	29.30	35.06
100	8.662	12.97	18.19	24.41	23.98	30.39	36.24
200	9.300	14.65	20.92	27.76	27.64	34.41	41.09
300	10.026	16.34	23.56	31.09	31.11	38.50	45.92
400	10.804	18.00	26.06	34.28	34.35	42.42	50.57
500	11.597	19.57	28.36	37.22	37.34	46.00	54.81
600	12.38	21.05	30.46	39.88	40.07	49.23	58.61
700	13.14	22.42	32.39	42.32	42.55	52.20	62.10
800	13.87	23.70	34.17	44.57	44.82	54.90	65.30
900	14.56	24.90	35.82	46.65	46.90	57.45	68.26
1000	15.22	26.03	37.35	48.57	48.83	59.78	70.99
1100	15.84	27.08	38.77	50.37	50.61	61.94	73.52
1200	16.43	28.05	40.10	52.03	52.26	63.95	75.87
1300	16.99	28.96	41.33	53.58	53.78	65.82	78.05
1400	17.50	29.81	42.47	55.00	55.20	67.53	80.06
1500	17.98	30.61	43.52	56.31	56.52	69.11	81.91
1600	18.43	31.33	44.49	57.54	57.73	70.59	83.63
1700	18.87	31.99	45.37	58.70	58.88	71.96	85.24
1800	19.27	32.62	46.21	59.75	59.86	73.23	86.69
1900	19.64	33.20	47.00	60.68	60.85	74.38	88.07
2000	19.97	33.74	47.71	61.61	61.72	75.46	89.36
2100	20.29	34.25	48.37	62.42	62.60	76.47	90.48
2200	20.58	34.70	49.00	63.18	63.35	77.34	91.60
2400	21.14	....	....	....	....	....	....
2800	22.01	....	....	....	....	....	....
3000	22.35	....	....	....	....	....	....
3500	23.01	....	....	....	....	....	....
4000	23.57	....	....	....	....	....	....

TABLE 6

Heat capacities of paraffinic hydrocarbons, C_1-C_6
Btu/lb.-mole ° °R.

°R.	C_1	C_2	C_3	n-C_4	i-C_4	n-C_5	n-C_6
492	8.295	11.856	16.32	22.16	21.41	27.57	33.05
500	8.340	11.98	16.51	22.42	21.71	27.88	33.41
520	8.439	12.304	17.10	23.08	22.46	28.69	34.35
537	8.536	12.585	17.57	23.60	23.14	29.30	35.06
600	8.92	13.66	19.28	25.75	25.48	31.93	38.16
700	9.58	15.34	21.98	29.06	29.07	36.04	43.02
800	10.34	17.02	24.56	32.36	32.45	40.07	47.78
900	11.12	18.66	26.98	35.46	35.62	43.85	52.27
1000	11.91	20.19	29.20	38.29	38.51	47.28	56.33
1100	12.68	21.63	31.23	40.86	41.14	50.41	60.01
1200	13.43	22.96	33.10	43.22	43.53	53.28	63.38
1300	14.15	24.21	34.83	45.40	45.70	55.91	66.48
1400	14.82	25.38	36.43	47.42	47.73	58.39	69.35
1500	15.46	26.48	37.92	49.29	49.60	60.63	72.00
1600	16.08	27.47	39.30	51.04	51.32	62.78	74.46
1700	16.66	28.45	40.59	52.65	52.93	64.70	76.74
1800	17.19	29.33	41.79	54.14	54.40	66.50	78.85
1900	17.69	30.15	42.92	55.52	55.78	68.16	80.80
2000	18.16	30.92	43.91	56.80	57.05	69.70	82.60
2100	18.61	31.59	44.84	58.00	58.24	71.14	84.27
2200	19.03	32.24	45.71	59.12	59.32	72.47	85.92
2300	19.42	32.85	46.53	60.12	60.34	73.69	87.24
2400	19.77	33.42	47.28	61.05	61.27	74.81	88.59
2500	20.10	33.94	47.97	61.93	62.13	75.86	89.81
2600	20.41	34.43	48.62	62.72	62.93	76.82	90.93
2700	20.71	....	....	....	....	....	....
2800	21.24	....	....	....	....	....	....
3200	21.88	....	....	....	....	....	....
3600	22.59	....	....	....	....	....	....
4000	23.05	....	....	....	....	....	....
4500	23.61	....	....	....	....	....	....

TABLE 7

Enthalpies of paraffinic hydrocarbons, C_1-C_6
cal./g-mole.

°C.	C_1	C_2	C_3	n-C_4	i-C_4	n-C_5	n-C_6
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	150.8	218.1	302.2	408.6	396.4	508.0	608.3
25	210.3	305.4	423.5	572.3	556.6	711.4	851.7
100	881.4	1337	1871	2513	2457	3123.0	3738.1
200	1882	2972	4235	5627	5582	6981	8337
300	3028	4901	7021	9294	9268	11501	13731
400	4313	7100	10186	13440	13420	16610	19807
500	5730	9525	13680	17944	17960	22213	26460
600	7266	12154	17450	22870	22920	28220	33590
700	8911	14950	21460	28060	28130	34600	41170
800	10650	17920	25680	33530	33630	41330	49130
900	12480	21020	30110	39240	39370	48330	57440
1000	14385	24240	34680	45160	45330	55580	66040
1100	16360	27580	39400	51250	51390	63060	74890
1200	18390	31010	44230	57500	57630	70720	83950
1300	20470	....	....	....	....	....	....
1500	24760	....	....	....	....	....	....
1700	29200	....	....	....	....	....	....
2000	36040	....	....	....	....	....	....
2200	40710	....	....	....	....	....	....

NOTE—Tables 8, 9, 10, 11, 12 and 13 on next page.

FURTHER ENTHALPY AND HEAT CAPACITY TABLES.——(See Kobe-Long Article on Preceding Pages.)

TABLE 8

Enthalpies of paraffinic hydrocarbons, C_1-C_5
cal./g-mole.

°K.	C_1	C_2	C_3	n-C_4	i-C_4	n-C_5	n-C_6
273	0.0	0.0	0.0	0.0	0.0	0.0	0.0
291	150.8	218.1	302.2	408.6	396.4	508.0	608.3
298	210.3	305.4	423.5	572.3	556.6	711.4	851.7
300	227.1	330.6	458.7	619.7	603.0	770.2	922.1
400	1133	1746	2460	3292	3256	4089	4891
500	2175	3460	4944	6559	6531	8131	9709
600	3359	5466	7834	10364	10352	12820	15299
700	4681	7730	11094	14624	14632	18070	21540
800	6131	10210	14660	19264	19304	23780	28330
900	7697	12890	18500	24230	24320	29900	35580
1000	9370	15730	22570	29500	29630	36380	43270
1100	11130	18740	26850	35040	35190	43180	51330
1200	12980	21870	31320	40800	40970	50250	59720
1300	14910	25130	35930	46780	46960	57570	68380
1400	16900	28490	40680	52910	53110	65100	77310
1500	18940	31950	45550	59190	59410	72800	86410
1600	21040	....	....	....	....	....	....
1800	25350	....	....	....	....	....	....
2000	29810	....	....	....	....	....	....
2200	34370	....	....	....	....	....	....
2500	41360	....	....	....	....	....	....

TABLE 9

Enthalpies of paraffinic hydrocarbons, C_1-C_9
Btu/lb.-mole.

°F.	C_1	C_2	C_3	n-C_4	i-C_4	n-C_5	n-C_6
32	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60	234.3	338.2	467.8	633.4	614.2	787.6	943.6
77	378.6	549.8	762.3	1030	1001	1280	1533
100	576.3	843.7	1174	1582	1544	1966	2353
200	1474	2225	3114	4184	4086	5201	6227
300	2430	3775	5340	7128	7032	8851	10579
400	3470	5492	7827	10395	10315	12890	15396
500	4590	7366	10539	13970	13910	17310	20653
600	5790	9401	13470	17830	17780	22060	26323
700	7065	11584	16620	21940	21910	27130	32355
800	8416	13900	19940	26290	26270	32490	38720
900	9827	16330	23450	30850	30860	38100	45400
1000	11330	18880	27110	35600	35640	43950	52350
1100	12880	21540	30920	40540	40610	50020	59540
1200	14490	24290	34870	45640	45750	56310	66990
1300	16170	27130	38940	50900	51030	62780	74670
1400	17890	30050	43110	56310	56470	69430	82570
1500	19660	33060	47470	61890	62050	76280	90670
1600	21470	36190	51840	67590	67800	83280	98950
1700	23350	39340	56340	73400	73670	90350	107390
1800	25260	42560	60930	79330	79600	97640	116000
1900	27210	45870	65560	85370	85590	105000	124760
2000	29190	49210	70320	91470	91690	112480	133650
2100	31210	52600	75080	97630	97910	120200	142660
2200	33210	56060	79970	103910	104190	127800	151750
2400	37420	....	....	....	....	....	....
2800	46050	....	....	....	....	....	....
3000	50480	....	....	....	....	....	....
3500	61870	....	....	....	....	....	....
4000	73440	....	....	....	....	....	....

TABLE 10

Enthalpies of paraffinic hydrocarbons, C_1-C_9
Btu/lb.-mole.

°R.	C_1	C_2	C_3	n-C_4	i-C_4	C_5	C_6
492	0.00	0.00	0.0	0.0	0.0	0.0	0.0
500	66.54	95.34	131.3	178.3	172.5	221.4	265.8
520	234.3	338.2	467.8	633.4	614.2	787.6	1533
537	378.6	549.8	762.3	1030	1001	1280	2353
600	927	1381	1943	2620	2581	3204	3901
700	1850	2832	4004	5362	5274	6620	7968
800	2846	4430	6335	8435	8326	10408	12506
900	3918	6234	8912	11825	11740	14604	17499
1000	5070	8177	11712	15514	15450	19160	22921
1100	6300	10268	14730	19470	19410	24040	28736
1200	7605	12497	17950	23680	23650	29230	34900
1300	8980	14855	21350	28110	28110	34690	41400
1400	10430	17335	24920	32750	32770	40400	48180
1500	11950	19930	28640	37580	37640	46350	55230
1600	13530	22630	32500	42580	42690	52530	65520
1700	15160	25420	36490	47740	47870	58900	70060
1800	16860	28310	40610	53090	53200	65460	77830
1900	18600	31290	44840	58540	58740	72190	85810
2000	20380	34340	49200	64170	64370	79090	93980
2100	22220	37450	53640	69930	70220	86130	102330
2200	24110	40630	58170	75770	76040	93310	110840
2300	26050	43880	62780	79750	82030	100620	119500
2400	28000	47220	67460	87810	88000	108040	128310
2500	30000	50560	72220	93930	94260	115570	137250
2600	32020	53990	77040	100140	100420	123210	146290
2700	34080	....	....	....	....	....	....
2900	38270	....	....	....	....	....	....
3200	44740	....	....	....	....	....	....
3600	53650	....	....	....	....	....	....
4000	62790	....	....	....	....	....	....
4500	74440	....	....	....	....	....	....

TABLE 11

Mean heat capacities of paraffinic hydrocarbons, C_1-C_6
cal./g-mole · °C.

°C.	C_1	C_2	C_3	n-C_4	i-C_4	n-C_5	n-C_6
0	8.295	11.856	16.32	22.17	21.41	27.57	33.05
18	8.378	12.117	16.79	22.70	22.02	28.22	33.79
25	8.413	12.22	16.94	22.89	22.24	28.44	34.07
100	8.814	13.37	18.71	25.13	24.57	31.23	37.36
200	9.41	14.86	21.18	28.14	27.91	34.91	41.69
300	10.09	16.34	23.40	30.98	30.89	38.34	45.77
400	10.78	17.75	25.47	33.60	33.55	41.53	49.52
500	11.46	19.05	27.36	35.97	35.98	44.42	52.92
600	12.11	20.26	29.08	38.12	38.20	47.03	55.98
700	12.73	21.36	30.66	40.09	40.19	49.43	58.81
800	13.31	22.40	32.10	41.91	42.04	51.66	61.41
900	13.87	23.36	33.46	43.60	43.74	53.70	63.82
1000	14.39	24.24	34.68	45.16	45.33	55.58	66.04
1100	14.87	25.07	35.82	46.59	46.72	57.33	68.08
1200	15.33	25.84	36.86	47.92	48.03	58.93	69.96
1300	15.75	....	....	....	....	....	....
1500	16.51	....	....	....	....	....	....
1700	17.18	....	....	....	....	....	....
2000	18.02	....	....	....	....	....	....
2200	18.50	....	....	....	....	....	....

TABLE 12

Mean heat capacities of paraffinic hydrocarbons, C_1-C_9
Btu/lb.-mole · °F.

°F.	C_1	C_2	C_3	n-C_4	i-C_4	n-C_5	n-C_6
32	8.295	11.856	16.32	22.16	21.41	27.57	33.05
60	8.368	12.079	16.71	22.62	21.94	28.13	33.70
77	8.413	12.22	16.94	22.89	22.24	28.44	34.07
100	8.475	12.41	17.26	23.26	22.71	28.91	34.60
200	8.77	13.24	18.54	24.90	24.32	30.96	37.06
300	9.07	14.09	19.92	26.60	26.24	33.09	39.47
400	9.43	14.92	21.27	28.25	28.03	35.03	42.04
500	9.81	15.74	22.52	29.85	29.72	36.99	44.13
600	10.19	16.55	23.71	31.39	31.30	38.84	46.34
700	10.58	17.34	24.88	32.84	32.80	40.61	48.44
800	10.96	18.10	25.96	34.23	34.20	42.30	50.42
900	11.32	18.81	27.02	35.54	35.55	43.89	52.30
1000	11.70	19.50	28.01	36.78	36.82	45.40	54.06
1100	12.06	20.27	28.95	37.96	38.02	46.84	55.75
1200	12.41	20.80	29.85	39.08	39.17	48.21	57.35
1300	12.75	21.40	30.71	40.14	40.24	49.51	58.89
1400	13.08	21.97	31.51	41.16	41.28	50.75	60.36
1500	13.39	22.54	32.31	42.16	42.27	51.96	61.76
1600	13.69	23.08	33.06	43.11	43.24	53.11	63.11
1700	14.00	23.59	33.78	44.00	44.17	54.17	64.38
1800	14.29	24.07	34.46	44.87	45.02	55.25	65.61
1900	14.57	24.56	35.10	45.70	45.82	56.21	66.79
2000	14.83	25.01	35.73	46.48	46.59	57.15	67.91
2100	15.09	25.44	36.31	47.21	47.35	58.12	68.98
2200	15.32	25.86	36.89	47.93	48.06	58.95	71.00
2400	15.80	....	....	....	....	....	....
2800	16.64	....	....	....	....	....	....
3000	17.01	....	....	....	....	....	....
3500	17.84	....	....	....	....	....	....
4000	18.51	....	....	....	....	....	....

TABLE 13

Heat capacity equations[1] of paraffinic hydrocarbons, C_1-C_6
cal./g-mole · °C. or °K. Btu/lb.-mole · °F. or °R.

$$C_p^\circ = a + b(t) + c(t^2) + d(t^3)$$

		a	b · 10^2	c · 10^6	d · 10^9	ERROR Max. Percent	ERROR Avge Percent
Methane:	°C.	8.200	1.307	0.08750	−2.630	1.28	0.67
	°K.	4.750	1.200	0.3030	−2.630	1.33	0.57
	°F.	7.971	0.7241	0.03125	−0.4510	....	....
	°R.	4.750	0.6667	0.09350	−0.4510	....	....
Ethane:	°C.	11.800	3.326	−1.390	1.740	0.87	0.30
	°K.	1.648	4.124	−1.530	1.740	0.83	0.28
	°F.	11.217	1.875	−0.4310	0.2984	....	....
	°R.	1.648	2.291	−0.4722	0.2984	....	....
Propane:	°C.	16.260	5.398	−3.134	7.580	0.42	0.12
	°K.	−0.966	7.279	−3.755	7.580	0.40	0.12
	°F.	15.311	3.061	−0.9800	1.300	....	....
	°R.	−0.966	4.044	−1.159	1.300	....	....
n-Butane	°C.	22.060	6.663	−3.697	8.360	0.60	0.24
	°K.	0.945	8.873	−4.380	8.360	0.54	0.24
	°F.	26.016	3.776	−1.154	1.433	....	....
	°R.	0.945	4.929	−1.352	1.433	....	....
iso-Butane	°C.	21.382	7.202	−4.519	11.92	0.30	0.14
	°K.	−1.890	9.936	−5.495	11.92	0.25	0.13
	°F.	20.112	4.090	−1.404	2.044	....	....
	°R.	−1.890	5.520	−1.696	2.044	....	....
n-Pentane	°C.	27.450	8.148	−4.538	10.10	0.63	0.23
	°K.	1.618	10.85	−5.365	10.10	0.56	0.21
	°F.	26.016	4.615	−1.417	1.732	....	....
	°R.	1.618	6.029	−1.656	1.732	....	....
n-Hexane:	°C.	32.850	9.763	−5.716	13.78	0.84	0.21
	°K.	1.657	13.19	−6.844	13.78	0.72	0.20
	°F.	31.131	5.536	−1.786	2.363	....	....
	°R.	1.657	7.329	−2.112	2.363	....	....

Maximum and average percent error from 0 to 1200° C. and 300 to 1500° K. on integral hundred degree increments.

[1] Temperature Ranges: 0—1200° C. 273—1500° K. 32—2200° F. 492—2600° R

***CARBON DIOXIDE** is present in objectionable concentrations in the gas production of some oil fields. This article outlines the measures adopted by one company to upgrade their field gas production for sales purposes through the removal of CO_2, and at the same time to develop a valuable new product, "dry ice," which is manufactured from what would otherwise be just another waste gas stream vented to the atmosphere. Presentation of the original paper, of which this article is a very slightly condensed version, was before the California Natural Gasoline Association, on December 2, 1948.*

Dry Ice Manufactured from CO_2 Extracted from Natural Gas

C. D. GARD
Union Oil Company of California, Los Angeles

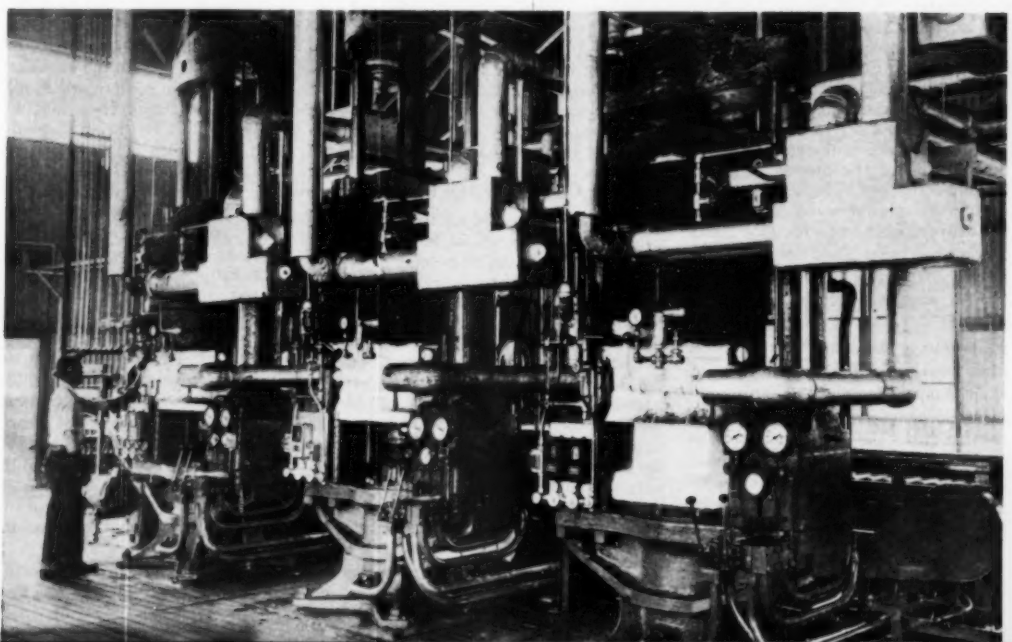
NATURAL gas produced in the Santa Maria oil field of California is in several respects unlike that produced in general from other California fields in that it has a relatively low 21.9 natural gasoline of 0.86 gallons per thousand, a low liquefied gas content, 0.75 gallons per thousand, is high in CO_2 with 16 percent average, relatively high in hydrogen sulphide content with 34 grains per 100 cubic feet average, and a low heating value of 950-960 range. All gas is produced at low pressures only. The field was initially developed in the early 1930's, but production on a large scale was not attained until 1938. Later, during the period from 1938 to 1941, the productive area was rapidly extended, and since that time there has been steady development which has reached the present productive acreage. The oil is of low gravity in the general range 12 to 16° API with some oil produced from wells having API gravity as low as 6.

Because of the many adverse economic factors affecting the gas processing, this feature of the field development was slow, and it was not until after World War II began that conditions warranted the full development of a processing program. Prior to this time, the demand for low-gravity, high-sulphur, crude oil was such that the crude oil output was not substantial, and since the gas oil ratios were low, being of the order of 300, the total volume of gas did not justify the expense to gather and process the entire field gas output.

Natural Gas Processing

The processing program has been developed in about three successive stages as follows:

1) During the period prior to 1943, the gas from Union Oil leases only was



Dry ice presses of Union Oil Company of California's plant viewed from the operating side. The press at the left is being filled with liquid, the press in the center is "snowing," and the press at the right has just ejected a dry ice cake from the press chamber.

compressed by one 150-hp. unit to approximately 75 psig. and delivered through pipe line to an existing plant, seven miles south of the Santa Maria field. Here the gas was commingled with gas produced in this area (Orcutt field), the gasoline and some LPG fractions removed, the residue gas purified of H_2S and delivered to a gas company for sale.

Plant Constructed

2) During the latter part of 1942, plans were made for the gathering of all wet, unconserved gas in the entire Santa Maria field and the processing of this gas in an absorption plant to be constructed at the location of the original compressor, other compressors being added to handle the new volumes of gas. This plant's capacity was 18,000 mcf. daily, with the gas being compressed from around 22 to 80 psig. where it was contacted in two soda ash towers for removal of a portion of the H_2S. The H_2S at that time was about 12-15 grains per 100 cubic feet and the CO_2 content only about 8-9 percent. The gas was next compressed to approximately 200 psig., partly cooled and contacted in beds of dry iron oxide impregnated wood shavings for the final removal of H_2S. The gas was then cooled and contacted in two 200 psig. oil absorbers for the removal of natural gasoline and some LPG fractions. This plant was largely built with equipment salvaged where available, and under the circumstances, did not have the benefit of latest design in equipment. An additional compressor was installed later to increase the capacity of the plant to around 22,000 mcf. daily.

With these facilities some gas was delivered directly to the Southern Counties Gas Company for sale at around 200 psig. for local consumption, the balance being delivered to our Orcutt plant for recompression to 400 psig. for sale to the gas company; this gas being transported to other localities for use. The gas company during this period installed a glycol gas dehydration plant within the Santa Maria absorption plant site and made several changes in their transport system to accommodate the larger gas volumes.

3) During the latter part of 1945, plans were laid for the addition of other compressors and a 450-psig. absorber to again increase the volume of gas handled. The work included the conversion of a portion of the former 200-psig. residue gas system to 450 psig. for delivery of gas direct to the gas company's transport system, this gas going to areas south of the Santa Maria field. Also, the installation of a new 450 psig. residue gas system and changes in the gas company's facilities for transporting increased volume of gas to areas north of the field. Changes were also made in the liquid fractionation cycle to retain additional volumes of light liquid fractions and the gas company installed a 450-psig. glycol gas dehydration plant. As the result of these changes, the plant processing capacity was increased to approximately 30,000 mcf. of gas per day. A little later, a 300-hp. injection compressor was installed in Cat Canyon, another oil field approximately eight miles to the southeast to conserve a portion of the residue gas from the absorption plant.

CO_2 and H_2S Extraction

Prior to this last increase in plant capacity, the CO_2 content of the residue gas had been gradually increasing and had reached objectionable concentrations in the residue gas delivered to the gas company, and it soon became evident that with a new residue gas sales contract in the making, a more favorable price for the gas could be obtained by removal of sufficient CO_2 to assure delivery to the gas company of 1000-Btu. gas. At the same time, the H_2S content had slowly increased from a former content of 12 grains per 100 cubic feet to around 30 grains.

Two programs were initiated to improve these conditions: a) The plans for a CO_2 extraction plant, and b) an investigation for development of a more effective means of removing greater quanties of H_2S in the primary or 80-psig. plant as the operation of the dry oxide beds was becoming expensive. At the same time, with the increasing CO_2 content, the amount of H_2S removed by the soda ash contactors became less, the sodium carbonate being rapidly converted to bicarbonate by the CO_2.

The CO_2 Extraction Plant

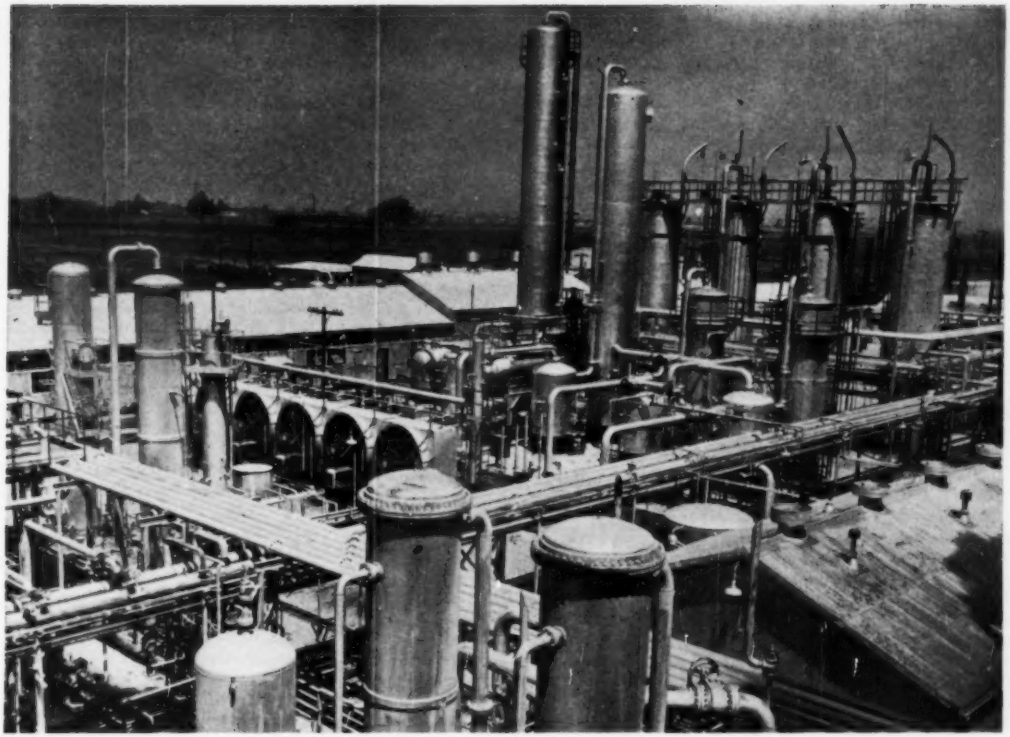
The plans for building the extraction plant materialized in June, 1947, after reviewing various processes for CO_2 removal. The selection of the Girbotol system was made after consideration had been given to the possible manufacture of dry ice from the extracted CO_2, as it was believed that the minimum H_2S content of the extracted CO_2 resulting from the use of this process would be an advantage if dry ice were made. The design of the process was made by the Girdler Corporation of Louisville, Ky., using monoethanolamine as the solvent, it being more favorable for the extraction of the CO_2 with minimum H_2S content.

The completed plant was placed in operation in May, 1948. Details of the process as developed employ a 20 percent solution of monoethanolamine with water. This solution is pumped over the top of a 20-tray absorber, 90 inches in diameter, with an over-all height of 49 feet, 9 inches, having a design pressure of 127 psig. The design liquid rate is 280 gallons per minute and the design gas throughput 30,000 mcf. per day at 80 psig. The enriched solution leaves the base of the absorber through a liquid level control valve passing through a set of three exchangers, where it is heated by the hot lean solution from the reactivator, and then to the twenty-first tray of a 23-tray reactivator, 72 inches in diameter and having an over-all height of 59 feet, 9 inches with design pressure of 94 psig. and a design vapor capacity of 2100 mcf. per day of CO_2 and 6112 pounds of steam per hour. The amount of CO_2 extracted at present is approximately 2300 mcf. daily. The hot amine solution in the reactivator is contacted by steam vapor generated in two reboilers operating in parallel.

Heating steam for reboilers is obtained from the turbine exhaust of steam driven pumps and fans. Exhaust steam from the absorption plant, formerly going to the atmosphere was conserved to give additional heating steam. Any deficiency in heating steam is supplied directly from the main steam header operating in the range of 150-155 psig. The flow of steam to the reboilers is volume-controlled through a flow controller.

The reheated amine solution after passing through the reboilers is returned to the base of the reactivator and from there it goes to the exchangers, then to multifin coolers, where the temperature is reduced from 200° F. to approximately 130°. From the multifin unit, the cooled solution goes to the final water-cooled closed coolers, where the temperature is reduced to approximately 100°. The cooled lean solution then goes to a centrifugal pump driven by a 32-hp. steam turbine, operating at 3550 rpm. The cooled lean solution from the pump returns to the 19th tray of the absorber, thus completing the cycle. A flow controller on the liquid line to the absorber controls the solution rate.

The CO_2 gas stripped from the rich amine, together with the steam generated in the reactivator, leaves the reactivator in two streams, one from the top of the reactivator, the other from the vapor space above tray 20. This feature was incorporated to provide



Picture of general arrangement of Union Oil plant and the absorption plant area. Two columns in center are the amine absorber on the right and the amine activator on the left. The two short columns on the right of the absorber are the soda ash-ferrox contactors and the four larger columns at the rear are the dry oxide beds.

a choice of selecting the CO_2 stream that would have the lowest H_2S content for processing in the dry ice plant, providing such a plant was constructed. Each of these streams is separately cooled and the water condensed by first passing through sections of the multifin cooler. The final cooling of the two CO_2 gas streams is accomplished by closed shell and tube type coolers, the water being supplied by a Byron Jackson gas engine driven circulating pump. The temperature on the overhead stream being cooled from 212° to 85° F. in the multifin unit and to a final temperature of approximately 75° F. in the final cooler. The side cut stream is similarly cooled from 220° to 85° F., the final temperature being approximately 75° F.

Vapors and water condensate from the final vapor coolers then pass to two separate accumulators, where the gas is vented and the condensate collected and returned to the system by a common pump with two separate liquid discharges. One of these liquid streams, about 2.5 gallons per minute, is returned to tray 23 of the reactivator, the other stream is returned to tray 20 of the absorber. The purpose of returning this condensate is to conserve any amine present and to reduce the carry-over of the amine in the overhead streams from the reactivator and the absorber. Control equipment was installed to vent the overhead stream and further process the side cut stream in any desired quantity or the mixing of the two streams and the processing of a portion of the mixture.

The multifin units are of the horizontal type with four 12-foot fans each supplying approximately 128,000 cubic feet per minute for cooling the hot lean amine, the reactivator overhead and side cut vapors. These fans are driven by 15-hp. turbines operating at 2200 rpm. driving the fans through geared speed reducing units, the fans operating at a normal speed of 328 rpm. The exhaust steam from the fan turbines and solution turbine at approximately 55 pounds back pressure is used for heating steam in the two reboiler units as previously described. The steam condensate formed in the two reboilers is collected in an accumulator at approximately 50 psig. from which it is returned to the boiler feed by means of a 12-7-16-inch steam pump.

In order to provide steam for the plant, it was necessary to install additional boilers, having a generating capacity of 21,000 pounds of steam per hour. Boilers will operate at a normal rating of 21,000 pounds per hour, but each boiler is capable of producing the maximum steam requirement should the other boiler be down for repairs or cleaning. Gas is used for fuel and the flue gases are vented into a common stack, the main body of which is 48 inches in diameter with a top 130 feet above ground level.

The Redistillation Unit

A redistillation unit was installed to provide a means of removing residues formed in the amine solution. This unit employs a reboiler unit through which a small stream of approximately one gallon per minute of

amine is circulated for cleaning. Steam heat is supplied to the heating coils of the reboiler. The unit operates at atmospheric pressure and the overhead purified stream is returned to the circulating system. The principal impurities which form the residue are thiosulphuric acid formed by a reaction between H_2S and oxygen and soda ash entering the solution from the soda ash contactors. The residue accumulates on the heating coils of the reboiler, and in time the heat transfer is reduced to the point where it becomes necessary to shut off the amine stream and agitate the heavy residue mass and accumulation on the tubes with steam entering a distribution pipe at the bottom of the reboiler. This operation is repeated, draining and refilling with fresh water until the heavy residue has been removed.

H_2S Extraction Plant

The original equipment installed at the plant for the removal of H_2S from the natural gas consisted of two contactors in which the natural gas was contacted by a soda ash solution, the solution being aerated in a small forced-draft type cooling tower. After aeration, the solution was pumped from the basin of the tower to the contactors. To reduce the effects of H_2S on the process equipment, the incoming gas after being compressed from approximately 20 to 80 psig., was contacted in the soda ash contactors, further compressed to around 200 pounds, at which pressure, the final purification of the gas was obtained by passing it through beds of iron oxide impregnated wood shavings before going to the 200-pound absorbers or additional compression for that portion of the gas processed in the 500-pound absorber.

In reviewing the various possibilities for improving the extraction in the soda ash towers, the idea of carrying finely divided iron oxide suspended in the soda ash solution seemed to offer possibilities. A trial operation was made using ferric chloride as a source for the iron. It was noted that the iron rapidly turned to iron sulphide, and the H_2S content of the exit gas was considerably reduced. Many difficulties with this process, however, were experienced; these difficulties being chiefly in the reconversion of the iron sulphide to iron oxide before returning to the contactors. A great deal of work was done along this line and the process that was eventually developed uses a soda ash solution in which is suspended the iron oxide. After passing through the contactors, the foul solution is vented in a separator to remove as much of the hydrocarbon gas as possible. It then passes through a series of long, horizontal troughs in which the foul solution is agitated with air, converting the iron sulphide to free sulphur which floats to the top of the liquid, and iron oxide which remains suspended in the solution. The free sulphur slurry is removed from the troughs by skimming and the reactivated solution is returned to the contactors to complete the cycle.

As a result of this development, the H_2S content of the gas is reduced from an average intake of 34 grains per 100 cubic feet to an outlet of 3-4 grains per 100 cubic feet. Ferric chloride is still used as the source of the iron oxide, and the over-all H_2S removal operating cost has been considerably reduced. The sulphur in the slurry is in the pure form; however, associated with it is a high percentage of water with some soda ash and iron oxide. No process changes have been made in the operation of the dry oxide beds and their replacement cost has been materially lessened. In an attempt to derive an income from the sulphur removed by this process, amounting to approximately 1100 pounds per day, the H_2S slurry is presently being washed with waste water from the cooling tower system. This water is normally wasted to control the concentration of total dissolved solids for the purpose of lessening scale deposits on the cooling and condensing equipment of the absorption plant system. This washing is quite effective in increasing the sulphur content of the slurry, and it now appears likely that a market can be developed for the sulphur, either in slurry form or in dry powder, the drying being an operation not now programmed.

The Dry Ice Plant

While the engineering of the CO_2 extraction plant was in progress, a proposition was submitted to company management for the installation and construction of facilities for converting the extracted CO_2 into dry ice on the assumption that a definite market existed for increased dry-ice production and that the anticipated revenue from the operation would be sufficient to retire the investment and show a profit in a reasonable time. The consumption of dry ice has rapidly increased in the past few years, the rate of increase being retarded by lack of ability, during the war years, to obtain material and equipment for installation of new plants.

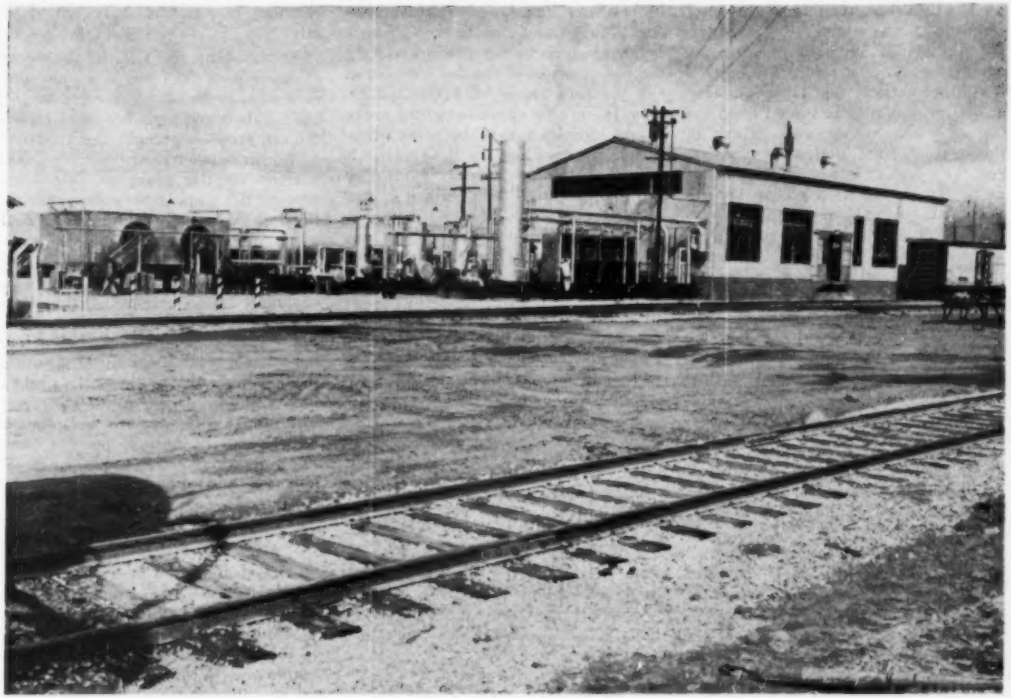
While the manufacture of dry ice is not a new industry, it may be interesting to review some of its sources and uses. Commercial carbon dioxide for the manufacture of dry ice is obtained from vent gases from boiler stacks, fermentation vats at industrial alcohol plants, chemical manufacturing plants, and natural wells producing carbon dioxide of relatively high purity. It is believed that the project at Santa Maria is the first plant to commercially extract carbon dioxide from natural oil well gas for the manufacture of dry ice.

The process of making dry ice as practiced at the Santa Maria plant involves the purification of that portion of the CO_2 stream vented from the reactivator overhead or side cut condenser which is to be processed for the manufacture of dry ice. There exists in the total CO_2 stream being removed from the natural gas stream approximately 130 tons of CO_2 per day. The maximum volume of CO_2 gas processed in the dry ice plant is anticipated to be approximately one-half this volume, the plant having a design rated capacity of 56 tons per day.

The ultimate design deviated from the practice of using supplemental refrigeration for obtaining low temperature CO_2 liquid. The CO_2 gas from the final condensers at the extraction plant is under approximately 20 psig. and, therefore, the total horse-power required to compress the CO_2 gas from this pressure to 1000 to 1100 psig., where cooling to atmospheric temperatures would give CO_2 liquid is not as great as had the pressure of this gas been around atmospheric, as is often otherwise the case. An engineering study of the problem indicated that it would be to our advantage to obtain the necessary low temperature CO_2 liquid by stage venting and recycling the vented vapors rather than applying mechanical refrigeration for this purpose.

Purification of the CO_2

In the selected process, the 20 psig. gas from the extraction plant is passed through two 48-inch double contact purification columns operating in series. The CO_2 gas stream enters the lower portion of the first of these two columns where it is contacted with a portion of the ferric oxide-soda ash solution used in our primary H_2S extraction plant. This contacting removes practically all of the H_2S in the CO_2 stream. The original design provided for contacting the gas in the upper portion of this first column with a solution of borax and potassium chromate. However, a short period of operation indicated that the solution was used up at such a rapid rate the cost



General view of dry ice plant and railroad spur. On extreme left is the CO_2 liquid storage. The smaller vessels are primary CO_2 liquid accumulator and flash drums. Dry ice press, storage bin and compressors are located within the building, with the dry ice car to the extreme right.

would be objectionable, and it is our plan to circulate our ferric oxide solution in the upper half replacing the chromate solution. The ferric oxide solution can be reactivated and no means were provided for reactivating the chromate solution. The CO_2 stream passes from the first column into the lower portion of the second column where it is contacted with potassium permanganate solution. The upper portion of the column also contacts the gas with permanganate solution. The spent solution from the lower portion is discarded and replaced by the partly spent solution from the upper portion. The upper portion is then recharged with fresh solution. The first column removes all of the H_2S and the second column will remove any traces of H_2S that might pass through as well as traces of amine which might give the ice an objectionable odor. The liquids are circulated through the columns at the rate of 30 gallons per minute, each liquid stream being separately pumped.

From the outlet of the second column the purified CO_2 stream is delivered to the intake of the compressors at the dry ice plant. Here the gas is compressed to 140 psig., cooled, and then goes to the second stage compressors, where the pressure is raised to 520 psig., then cooled, dehydrated, and further compressed to sufficient pressure to cause liquefaction to occur at the temperature of this stream leaving the final cooler. A maximum condition of 1100 psig. and 85° F. was anticipated.

CO_2 Dehydration

To avoid difficulty of freezing in the colder streams of CO_2 liquid and vapor, it became necessary to dehydrate the CO_2 gas stream prior to the liquid stage. This was accomplished by installation of a drying unit on the suction to the final stage of compression of CO_2. This gas dryer consists of two units which may be alternately placed in operation by means of a manifold. Each unit is filled with 1200 pounds of activated alumina and is capable of removing 7 pounds of water per hour from 12,000 pounds per hour of CO_2 gas with a final dew point of —40° F. The design pressure of the unit is 650 psig. The operating cycle is eight hours. The beds are reactivated by blowing air, heated by a steam heater, through the saturated bed and venting to atmosphere. The air is heated to about 320° F., and air from the dryer has an initial temperature of approximately 40°, gradually increasing as the temperature of the bed increases, reaching a maximum of approximately 250°. After five hours of heating, the steam is turned off from the air heater and the cooled air is permitted to flow through the vessel for approximately two hours. The vessel remains idle for approximately one hour and is then ready for placing on the line. The temperature of the dried CO_2 stream leaving the bed is in the range of 60 to 70°. The beds are continuously alternated.

It was realized that for short periods each year temperatures normally obtained by the conventional cooling tower method might be above the critical, in which case, no condensation would appear. The type of cooling tower selected, therefore, was an evaporative cooler. The unit selected employs two fans separately driven by gas engines. These engines also drive separate water circulating pumps. The fans are 5 feet in diameter, operating at 550 rpm. The pumps have a normal rating of 700 gallons at 1348 rpm. and 60-foot head. The fan drive is accom-

plished by V belt, the pumps are direct connected to the engine.

Liquid from the high pressure accumulator is float-controlled into a 3 x 8-foot vertical vent tank operating at 510 psig. Vapor is vented from the top of the separator and returns to the suction of the final stage compressor. The liquid leaves this separator at 35° F. and enters a second separator at 235 psig. The vent vapor returns to suction of the second stage compression. This separator is 104 inches in diameter and 33 feet in length, mounted in a horizontal position and serves as CO_2 liquid storage, the temperature being —10° F. From the storage vessel the liquid CO_2 is float-controlled into the 3 x 8-foot vertical final flash drum which is constructed of stainless steel, having a normal working pressure of 165 psig. Flash vapors from this vessel return to the suction of the second stage compression, and the liquid at minus 40° F. is piped to the dry ice presses.

The CO_2 gas received from the extraction plant and recycled from the dry ice plant is handled by two compressors. The final design of the plant was adjusted to a dry ice output based on 100 percent utilization of the available horsepower; that is, 600 horsepower. The jacket-water of these compressors is cooled by three radiator units having a total water circulation of 600 gallons per minute. The CO_2 gas handled in the compressors and the CO_2 gas vented from the presses as well as the quantity of dry ice is shown in the accompanying tables.

CO_2 Gas to Compressors

	1st STAGE		2nd STAGE		3rd STAGE	
	Lbs./Hr.	Percent of Total	Lbs./Hr.	Percent of Total	Lbs./Hr.	Percent of Total
Make-up Stream from Extraction Plant	5,480	60.89	5,480	45.31	5,480	24.94
CO_2 Gas from Ice Presses via Surge Tank	3,520*	39.11	3,520*	29.10	3,520*	16.02
CO_2 Gas Vent from Liquid CO_2 Storage Tank	....	....	1,985	16.41	1,985	9.03
Gas Vent from 150 Lb. W.P. Flash Drum	....	....	1,110	9.18	1,110	5.05
Con Gas Vent from 510 Lb. W.P. Final Accumulator	....	....	....	....	9,880	44.96
Total	9,000	100.	12,085	100.	21,975	100.

Horsepower per Day/Ton Dry Ice per Day = $\frac{600}{56}$ = 10.7

* Same Gas.

CO_2 to and from Dry Ice Presses

	Lbs./Hr.	Percent of Total
Dry Ice from Presses	4,660	51.78
Vent Loss to Atmosphere Unaccounted Loss	820	9.11
Blowback from Presses to Compressors	3,520	39.11
	9,000	100.

Dry Ice Presses

There are three dry ice presses, each capable of making 18 to 20 tons of dry ice per day. The presses are individually operated by electric motor-driven hydraulic pumps, there being two hydraulic systems, one of which raises and lowers the platen, and the other raises and lowers the compressor plunger and boosts the pressure being applied to the plunger during the compression of the dry ice cake in the pressure range of 2200 to 2500 psig. During the operation of the press, liquid initially enters the press where flashing occurs and the flash vapor is vented from the press chamber at approximately 80 psig., which is just above the triple point.

After the press chamber has been filled with the required amount of CO_2 liquid, the liquid feed is shut off and flashing continues. This requires approximately two minutes. This venting continues for another minute, during which the vent control valve is opened wide and the pressure in the press chamber decreases to around 40 psig. During these two periods, the gas vented from the press goes directly to the interchanger on the liquid stream between the high stage liquid CO_2 accumulator and the first stage flash drum. Here the temperature of the vented gas is raised from —80° F. to 0° F. and then goes to the CO_2 vapor surge drum. The gas from this chamber goes to the suction of the first stage compressor. A flow controller is used to prevent the full surge of the vent volume from entering the compressor.

At the close of this second period, venting continues through a second valve for one and one-half minutes directly to the suction of the first stage compressor until the pressure in the press chamber is approximately 20 pounds. The remaining vapor in the chamber is then manually vented to air.

At this time the CO_2 in the press chamber is in the form of a snow and is ready to be compressed into the cake. This is accomplished by lowering the compression plunger and applying hydraulic pressure of 2200 to 2500 pounds on the plunger. This compresses the snow into a cake having the approximate dimensions of 20 x 20 x 10 inches and weighing approximately 240 pounds. The cake is now ready to be ejected from the press chamber. This is accomplished by lowering the platen, the cake following the platen out of the press chamber. When the platen reaches its lower position the dry ice cake is manually pushed onto a power driven roller conveyor. The platen is then raised, the plunger returned to its normal position, and the operation repeated. The total elapsed time requires about seven minutes.

Sawing and Wrapping

After leaving the press, the dry ice cake travels to a band saw where the cake is cut vertically into two equal portions; the two halves then continue to the end of the conveyor, where an automatically controlled device pushes the two portions onto another conveyor at right angles. Here it passes through another band saw, where the cake is cut at right angles to the first cut, making four cakes of equal size with approximate dimensions of 10 x 10 x 10 inches. These cakes then proceed on the conveyor to the wrapping table where they are wrapped in a heavy manila bag, tape-sealed, and weighed on an automatic scale. The wrapped cake then is placed on another power driven conveyor for direct loading into the dry ice cars.

Car Loading

Specially constructed dry ice railroad cars are heavily insulated and are somewhat similar to the standard refrigerator car. Dry ice in the packaged form is placed in the cars, the net loaded weight of which is approximately 69,000 pounds.

A dry ice storage bin, 30 x 10 x 5 feet, insulated with 12 inches of insulation, has been provided adjacent to the scale for the storage of dry ice manufactured during the period no cars are immediately available.

A truck loading dock also has been provided.

* * *

Simplified Multicomponent Fractionation Calculations

Distribution of Split Key Components

(PART II)

RAYMOND V. BAILEY
and JESSE COATES

***THE PROBLEM** in multicomponent distillation of determining the correct distribution between the bottoms and overhead of components with volatilities intermediate between those of the key components has been handled in the past largely by trial and error. In this article methods of determining the distribution of these components, split key components, with a minimum of trial and error are presented.*

In Part I a simplifed method of handling this problem at minimum reflux by means of the Underwood equations was presented. The limitations of the Underwood equations for the case of varying relative volatilities were pointed out.

In the present article, Part II, a simplified method of applying the Colburn relation at minimum reflux to the determination of the distribution of split key components is presented.

A study has been made of the distribution of split keys which will give the optimum number of trays at reflux ratios other than total and minimum. The distribution of split keys obtained at total reflux was found to give a minimum number of trays at all reflux ratios except those very close to the minimum.

Mr. Bailey is a graduate student in Chemical Engineering and Dr. Coates is professor of Chemical Engineering, both at Louisiana State University.

THE application of Underwood's[7, 8, 9] equations for the distribution of split keys at minimum reflux was presented in Part I. However, due to the difficulty in selecting a proper temperature for the evaluation of relative volatilities, these equations are unreliable for systems in which the relative volatilities of the components vary appreciably with temperature. Therefore, equations are developed in this article for a systematic application of Colburn's[2] correlation for the distribution of split keys at minimum reflux.

The problem of the distribution of split keys at reflux ratios other than minimum and total reflux is also discussed.

Colburn Correlation for Distribution of Split Keys at Minimum Reflux:

For systems containing split keys Colburn[2] has shown that

1) $\frac{r_m}{r_n} = \psi$ at minimum reflux.

where r_m — ratio of the mols of the light key component to the heavy key component in the stripping pinch.

r_n — ratio of the mols of the light key component to the heavy key component in the fractionating pinch.

ψ — empirical factor defined by equation (11a).

2) The distribution of the split key is such that the ratio of the mols of the split key component in the fractionating pinch to that in the stripping pinch lies between the corresponding ratios of the light key component and the heavy key component.

However, for large values of ψ, there would be a considerable range of distributions of the split key component which would satisfy criterium (2). In addition, a tremendous amount of trial and error is encountered in trying to satisfy both conditions (1) and (2) without a straightforward procedure which gives a rapid convergence to the true values.

In an attempt to surmount these difficulties it has been assumed that for the key components there exists a linear relation of $(\alpha - 1)$ versus the ratio of the mols of the component in the fractionating pinch to that in the stripping pinch. In addition, the following equations have been developed in order to facilitate calculations.

For sharp separations of the key components in systems containing no components lighter than the light key component or heavier than the heavy key component the distribution of any intermediate components is given by

$$\frac{d_s}{d_n} = \frac{M_{sF}}{M_{nF}} \left| \frac{\alpha_s - 1}{\alpha_{lK} - 1} \right\} \left\{ \frac{d_{lK}}{M_{lK_F}} \left[\alpha_{lK} - \frac{m}{m+1} (\alpha_{lK} - \alpha_s) \right] + \frac{d_{hK}}{M_{hK_F}} \left[1 + \frac{m}{m+1} (\alpha_s - 1) \right] \right\} \quad (6)$$

where $m = \frac{M_L - \Sigma M_{hF}}{M_V - \Sigma M_{lF}}$

α — relative volatility with respect to the heavy key component.

d — mols of a component overhead.

m — pseudo ratio of liquid to vapor.

M — mols.

Subscripts:

F — feed

h — heavy component

hK — heavy key component

l — light component

lK — light key component

L — liquid in feed

s — split key component

V — vapor in feed.

A good first approximation for the distribution of split

keys for any system may be obtained by the application of equation (6).

By rearrangement of the equations of the operating lines at the pinches

$$K_{hK_n} = \left(1 + \frac{d_{hK}}{l_{hK_n}}\right)\left(\frac{L}{V}\right)_n \tag{7a}$$

$$K_{hK_n} \cong \left(\frac{L}{V}\right)_n \tag{7b}$$

$$K_{lK_m} = \left(1 - \frac{w_{lK}}{l_{lK_m}}\right)\left(\frac{L}{V}\right)_m \tag{8a}$$

$$K_{lK_m} \cong \left(\frac{L}{V}\right)_m \tag{8b}$$

$$l_s = \frac{d}{\left(\frac{VK}{L}\right)_s - 1} \tag{9}$$

$$l_m = \frac{w}{1 - \left(\frac{VK}{L}\right)_m} \tag{10}$$

NOMENCLATURE

- c — Correction factor
- d — Mols of a component in the overhead
- D — Total mols of overhead
- K — Equilibrium constant
- l — Mols of a component in the liquid phase
- L — Total mols of liquid downflow in tower
- M — Mols of a component (liquid plus vapor)
- m — Pseudo ratio of liquid to vapor
- q — Heat required to convert one mole of the feed to saturated vapor divided by the latent heat of the feed
- R — Mols of reflux per mol of overhead
- r — Ratio of mols of light key component to heavy key component
- S — Number of equilibrium steps
- V — Total mols of vapor upflow in tower
- w — Mols of a component appearing in the bottoms
- X — Mol fraction of a component in the liquid phase
- Z — Total mol fraction of a component (liquid plus vapor)
- α — Relative volatility of a component with respect to the heavy key component
- ψ — Empirical factor defined by equation (11a)
- ϕ — Defined by equation (1) and has a value between the relative volatilities of the key components

Subscripts:

- av — Average
- D — Overhead
- F — Feed
- f — Feed tray
- h — Heavy component (volatility less than that of the heavy key component)
- hK — Heavy key component
- l — Light component (volatility greater than that of the light key component)
- L — Liquid in feed
- lK — Light key component
- m — Stripping section
- M — Minimum
- n — Fractionating section
- s — Split key component
- T — Top of tower
- V — Vapor in the feed

Superscripts:

- ′ — Denotes uncorrected values

where K — equilibrium constant.
l — mols of a component in the liquid phase.
L — total mols of liquid downflow in tower.
V — total mols of vapor upflow in tower.
w — mols of a component appearing in the bottoms.

Subscripts:
m — stripping section
n — fractionating section.

The empirical factor, ψ, in Colburn's correlation is given by

$$\psi = \frac{L_s L_m}{(L_s - \Sigma c_l l_{l_n})(L_m - \Sigma c_h \alpha_h l_{h_m})} \tag{11a}$$

where c_l and c_h are correction factors given in graphical form in Colburn's article.

In many cases no serious error is encountered if the correction factors c_l and c_h are taken as unity. The expression can then be written in a more convenient form.

$$\psi = \frac{L_s L_m}{(L_s - \Sigma l_{l_n})\left[L_m - \frac{\Sigma l_{h_m} - \Sigma w_h}{\left(\frac{VK_{hK}}{L}\right)_m}\right]} \tag{11b}$$

where $\left(\frac{VK_{hK}}{L}\right)_m$ is obtained of a necessity in the calculations of the pinch compositions.

By noting that the mols of all components in the pinches, except the heavy key component in the fractionating pinch and the light key component in the stripping pinch, change only slightly with reflux ratio and that ψ is practically constant

$$l'_{hK_n} = \frac{F_1 + \sqrt{(F_1)^2 + 4F_2\psi}}{2} \tag{12}$$

$$\text{and } l'_{lK_m} = l'_{hK_n} - F_3 \tag{13}$$

where $F_3 = (l_{hK_m} + \Sigma l_{h_m}) - (l_{lK_n} + \Sigma l_{l_n}) - M_L$

$F_4 = (l_{lK_n})(l_{hK_m})$

Superscript (′) denotes values corresponding to assumed values of d_s.

The correction in the mols of the split key overhead in order to meet the criterium of a linear relation for the key components of $(\alpha - 1)$ versus the ratio of the mols of the component in the fractionating pinch to that in the stripping pinch is then given by

$$\Delta d_s = \frac{F_1 w'_s - d'_s}{1 + F_1 + F_2\left(\frac{d'_s}{l'_{hK_n} + l'_{hK_m}}\right)} \tag{14}$$

where $F_1 = \left(\frac{l_{lK_n}}{l'_{lK_m}}\right)\left[\frac{\left(\frac{VK_s}{L}\right)_s - 1}{1 - \left(\frac{VK_s}{L}\right)_m}\right]\left[\psi - (\psi - 1)\frac{\left(\frac{VK_s}{L}\right)_s - 1}{\left(\frac{VK_{lK}}{L}\right)_s - 1}\right]$

$$F_2 = \frac{1}{\left(\frac{VK_s}{L}\right)_s - 1} + \frac{1}{1 - \left(\frac{VK_s}{L}\right)_m}$$

The correspondingly corrected mols of the heavy key component in the fractionating pinch, light key component in the stripping pinch, liquid flow in the fractionating pinch, and minimum reflux in order that $\frac{r_m}{r_s}$ be qual to ψ are

$$l_{hK_n} = l'_{hK_n} - \sum \frac{F_s(\Delta d_s)}{1+\left(\frac{l_{lK_m}}{l_{hK_n}}\right)'} \quad (15)$$

$$l_{lK_m} = l'_{lK_m} + \sum \frac{F_s(\Delta d_s)}{1+\left(\frac{l_{hK_n}}{l_{lK_m}}\right)'} \quad (16)$$

$$L_n = \Sigma l_n + \sum \frac{\Delta d_s}{\left(\frac{VK_s}{L}\right)_s - 1} \quad (17)$$

$$R_M = \frac{L_n}{D' + \Sigma \Delta d_s} \quad (18)$$

Even though the list of equations appears quite lengthy and complicated, it should be noted that the expressions in most of the equations are obtained in the process of calculating the pinch compositions and that the calculations proceed quite rapidly.

Application of Equations

By use of equation (6) and approximate relative volatilities a first approximation of the split key distribution is obtained. A minimum reflux ratio is then assumed such that the temperature of the stripping pinch is slightly greater than the temperature of the fractionating pinch, the temperatures being obtained by means of equations (7b) and (8b). After applying equation (9) to all components lighter than the heavy key component and equation (10) to all components heavier than the light key component the value of ψ is obtained from equation (11). A first approximation of the mols of the heavy key component in the fractionating pinch and the light key component in the stripping pinch is obtained by means of equations (12) and (13), respectively. Then, from the application of equations (14), (15), (16), (17), and (18), corrected values of the distribution of the split key component, mols of the heavy key component in the fractionating pinch, mols of the light key component in the stripping pinch, liquid flow in the fractionating pinch and minimum reflux ratio are obtained. Using this new value of minimum reflux ratio and equations (7a) and (8a) to determine the temperatures at the pinches, the preceding calculations are repeated until the desired convergence is obtained. For most purposes the second trial gives sufficiently precise results.

The method is illustrated for constant volatility and for varying volatility by the same illustrative examples which were solved by Underwood's equations in Part I.

Illustrative Example III

As an example of the application of Colburn's correlation to a system of constant relative volatility, the following problem will be used.

Component	α	Mols Feed	d	w
A	4	15	15	....
B	2	15	15	trace
C	1.7	20	*17	3
D	1.3	20	*9.96	10.04
E	1.0	15	trace	15
F	0.5	15	.....	15
		100	56.96	43.04

* From equation (6).

Feed is saturated vapor. Components C and D are split keys.

Approximation of distribution of C and D by equation (6)

$$m = \frac{0-15}{100-15} = -.1765$$

$$m/(m+1) = -.1765/(1-.1765) = -.214$$

$$d_C = \frac{(20)(0.7)[2+(.214)(.3)]}{(1.7)(1.0)} = 17.0$$

$$d_D = \frac{(20)(.3)[2+(.214)(.7)]}{(1.3)(1.0)} = 9.96$$

It may be noted that for this sharp separation of the key components that

$$\left(\frac{VK}{L}\right)_n - 1 = \alpha - 1 \text{ and } 1 - \left(\frac{VK}{L}\right)_m = 1 - \frac{\alpha}{\alpha_{lK}}$$

	Fractionating Pinch		Stripping Pinch	
	(VK/L)−1	l_n	1−(VK/L)	l_m
A	3	5.0	....	.....
B	1	15.0	....	l_{mB}
C	0.7	24.3	.15	20
D	0.3	33.2	.35	28.7
E	....	l_{nE}	.50	30.
F	....	.....	.75	20.
		77.5+l_{nE}		98.7+l_{mB}

Assume $L_n = L_m = 110$

Then $\psi = \frac{110}{110-5} \Big| \frac{110}{110-(20-15)/.5} = 1.15$

$F_s = 98.7 - 77.5 - 0 = 21.2$

$F_c = (15)(30) = 450$

Then $l'_{mB} = \frac{21.2 + \sqrt{(21.2)^2 + (4)(450)(1.15)}}{2} = 35.65$

$l'_{mB} = 35.65 - 21.2 = 14.45$

Then $F_{1C} = (15/14.45)(.7/.15)[1.15-(.7)(.15)] = 5.06$

$F_{1D} = (15/14.45)(.3/.35)[1.15-(.3)(.15)] = .985$

$F_{2C} = 1/.7 + 1/.15 = 8.10$

$F_{2D} = 1/.3 + 1/.35 = 6.19$

Then by equation (14)

$$\Delta d_c = \frac{(5.06)(3)-17}{1+5.06+(8.1)(17)/50.1} = -0.2$$

$$\Delta d_D = \frac{(.985)(10.04)-9.96}{1+.985+(6.19)(9.96)/50.1} = -0.01$$

By equation (15)

$$l_{nE} = 35.65 + \frac{.2+.01}{1+(14.45/35.65)} = 35.8$$

By equation (17)

$$L_n = 77.5 + 35.8 - (.2/.7) - (.01/.3) = 113.0$$

By equation (18)

$$R_M = \frac{113.0}{56.96-.21} = 1.99$$

$d_C = 17.0 - .2 = 16.8$

$d_D = 9.96 - .01 = 9.95$

Further corrections are not essential since there was such a small change in the distribution of the split keys.

Illustrative Example IV

As another example of the application of the Colburn correlation the following depropanizer problem will be used.

	Mols Feed	d	w
C_3	3	3.0	....
C_3	7	7.0	....
C_3	15	14.7	0.3
C_4	33	*13.0	*20.0
C_4	30	0.2	29.8
C_5	12	....	12.0
	100	37.9	62.1

* First approximation from equation (6).

$q = .69$

Tower pressure = 200 psia.

Equilibrium data from nomograph by Scheibel (5).

Assume $R_M = 0.75$

Then $K_{hk_n} = 0.75/1.75 = 0.428$ by equation (7b)

Temperature of fractionating pinch = 196 F.

Use 196 F. as temperature to evaluate α's for equation (6).

	K^{196}	α
C_3	2.16	5.05
C_4	.948	2.21
C_5	.428	1.00

Then by application of equation (6)

$$m = \frac{69 - 12}{31 - 10} = 2.71$$

From equation (16)

$$l_{1K_m} = 9.67 + \frac{(2.71)\ (1.7)}{1 + (16.13/9.67)} = 11.40$$

From equation (17)

$$L_n = 14.94 + 13.25 + (1.7/1.22) = 29.58$$

From equation (18)

$$R_M = 29.58/(37.9 + 1.7) = 0.746$$

Using $R_M = .746$, $d_{c_4} = 14.7$ for next trial

$L_n = (.746)\ (39.6) = 29.6$ $\quad L_m = 29.6 + 69 = 98.6$

$V_n = (1.746)\ (39.6) = 69.2$ $\quad V_m = 69.2 - 31 = 38.2$

$(L/V)_n = .426$ $\quad (L/V)_m = 2.58$

$K_{hk_n} = [1 + (.2/13.25)](.426) = .434$ Temp. = 197 F.

$K_{1K_m} = [1 - (.3/11.4)](2.58) = 2.51$ Temp. = 222 F.

(See tabulation immediately below.)

	FRACTIONATING PINCH				STRIPPING PINCH			
	K^{197}	$\frac{VK}{L}$	$\frac{VK}{L} - 1$	l_n	K^{222}	$\frac{VK}{L}$	$1 - \frac{VK}{L}$	l_m
C_3	21.0	49.2	48.2	.0625	....	....	....	....
C_3	5.4	12.68	11.68	.600	....	....	....	....
C_3	2.15	5.05	4.05	3.625	2.51	....	....	l_{1K_m}
C_4	.95	2.22	1.22	12.05	1.15	.446	.554	33.0
C_5	.434	....	....	l_{hK_n}	.56	.217	.783	38.0
C_6	....	....	....	.....	.28	.109	.891	13.5
				$16.34 + l_{hK_n}$				$84.5 + l_{1K_m}$

$$d_{c_4} = \frac{(33)(1.21)}{(2.21)(4.05)} \left\{ \frac{14.7}{15.0} \left[5.05 - \frac{(2.71)(5.05 - 2.21)}{3.71} \right] + \frac{0.2}{30} \left[1 + \frac{(2.71)(2.21 - 1)}{3.71} \right] \right\} = 13.0$$

Then $w_{c_4} = 33 - 13 = 20$

Using $R_M = 0.75$

$L_n = (0.75)(37.9) = 28.4$ $\quad L_m = 28.4 + 69 = 97.4$

$V_n = (1.75)(37.9) = 66.3$ $\quad V_m = 66.3 - 31 = 35.3$

$K_{hk_n} \cong (L/V)_n = .428$ $\quad$ Temperature = 196 F.

$K_{1K_m} \cong (L/V)_m = 2.75$ $\quad$ Temperature = 237 F.

(See tabulation immediately below.)

$$\psi = \frac{29.6}{29.6 - .66} \Big| \frac{98.6}{98.6 - (1.5/.217)} = 1.10$$

$F_3 = 84.5 - 16.34 - 69 = -.84$

$F_4 = (3.625)\ (38) = 138$

$$l'_{hK_n} = \frac{-.84 + \sqrt{(.84)^2 + (4)\ (138)\ (1.10)}}{2} = 11.88$$

$l'_{1K_m} = 11.88 + .84 = 12.72$

$F_5 = (3.625/12.72)\ (1.22/.554)\ [1.10 - (1.22/4.05)\ (.10)] = .672$

$F_6 = 1/1.22 + 1/.554 = 2.63$

	FRACTIONATING PINCH				STRIPPING PINCH			
	K^{196}	$\frac{VK}{L}$	$\frac{VK}{L} - 1$	l_n	K^{237}	$\frac{VK}{L}$	$1 - \frac{VK}{L}$	l_m
C_3	21.0	49.0	48.0	.0625	....	....	....	....
C_3	5.42	12.68	11.68	.600	....	....	....	....
C_3	2.16	5.05	4.05	3.625	2.76	....	....	l_{1K_m}
C_4	.948	2.22	1.22	10.65	1.30	.471	.529	37.8
C_5	.428	....	....	l_{hK_n}	.65	.236	.764	39.0
C_6	....	....	....	.....	.329	.119	.881	13.6
				$14.94 + l_{hK_n}$				$90.4 + l_{1K_m}$

From equation (11b)

$$\psi = \frac{28.4}{28.4 - .663} \Big| \frac{97.4}{97.4 - (1.6/.236)} = 1.10$$

Using equation (12)

$F_3 = 90.4 - 14.94 - 69 = 6.46$

$F_4 = (3.625)\ (39) = 141.2$

$$l'_{hK_n} = \frac{6.46 + \sqrt{(6.46)^2 + (4)\ (141.2)\ (1.10)}}{2} = 16.13$$

$l'_{1K_m} = 16.13 - 6.46 = 9.67$

Using equation (14)

$F_5 = (3.625/9.67)\ (1.22/.529)\ [1.10 - (1.22)\ (.10)/4.05] = .935$

Then $F_6 = 1/1.22 + 1/.529 = 2.71$

$$\Delta d_{c_4} = \frac{(.935)\ (20) - 13.0}{1 + .935 + (2.71)\ (13)/25.8} = 1.7$$

From equation (15)

$$l_{hK_n} = 16.13 - \frac{(2.71)\ (1.7)}{1 + (9.67/16.13)} = 13.25$$

$$\Delta d_{c_4} = \frac{(.672)\ (18.3) - 14.7}{1 + .672 + (2.63/24.6)\ (14.7)} = -.74$$

$$l_{hK_n} = 11.88 + \frac{(2.63)\ (.74)}{1 + (12.72/11.88)} = 12.82$$

$$l_{1K_m} = 12.72 - \frac{(2.63)\ (.74)}{1 + (11.88/12.72)} = 11.71$$

$L_n = 16.34 + 12.82 - (.7/1.22) = 28.59$

$R_M = 28.59/(39.6 - .7) = .734$

$d_{c_4} = 14.7 - .74 = 13.96$

Repeating the calculations again

$R_M = 0.740$

$d_{c_4} = 14.04$

Distribution of Split Keys for Other Reflux Ratios

For any reflux ratio there is an optimum feed tray location or ratio of the key components at the feed tray which will give a minimum number of trays for that reflux ratio and a given separation of the key components. For a system containing split keys it is necessary to specify the distribution of the split keys between the overhead and

TABLE 1A

Comparison of Values of R_M and d_s at Minimum Reflux.

PROBLEM	FEED COMPOSITION					RELATIVE VOLATILITIES					FEED CONDITION
	l	lk	s	hk	h	α_l	α_{lK}	α_s	α_{hK}	α_h	q
1	25	25	25	25	..	4	2	1.5	1.0	....	1.0
2	..	25	25	25	25	..	2	1.5	1.0	0.5	1.0
3	..	25	25	25	25	..	2	1.5	1.0	0.8	1.0
4	40	15	20	25	..	6	2.2	2.0	1.0	....	0.0
5	25	25	25	25	..	4	2	1.5	1.0	....	0.535
6	25	25	25	25	..	2.5	2	1.5	1.0	....	1.0
7	15	15	{20* / 20†}	15	15	4	2	{1.7* / 1.3†}	1.0	0.5	0.0

* S_1. † S_2.
In all cases only a trace of the light key component appears in the bottoms and only a trace of the heavy component appears in the overhead.

TABLE 1B

Comparison of Values of R_M and d_s at Minimum Reflux.

PROBLEM	UNDERWOOD EQUATIONS		COLBURN CORRELATION		Equation 6	TRAY. CALC.	
	d_s	R_M	d_s	R_M	d_s	d_s	Rm
1	10.95	1.24	10.98	1.24	11.2	11.0	1.24
2	12.90	2.085	13.02	2.085	12.5	12.9	2.085
3	13.05	2.28	13.4	2.16	12.5	....	....
4	18.1	1.11	18.1	1.12	16.3	....	....
5	13.30	1.42	13.30	1.42	13.71	....	....
6	11.2	1.40	10.7	1.38	11.2	....	....
7	{d_{s1} 16.81 / d_{s2} 10.0}	2.00	{d_{s1} 16.8 / d_{s2} 9.95}	1.99	{d_{s1} 17.0 / d_{s2} 9.96}	....	....

bottoms before tray calculations can be made. This is in effect a specification of the feed tray location or ratio of the key components at the feed tray since there is only one point at which the concentrations of all components can be matched after the distribution of the split key has been specified. Thus, it is necessary to use trial and error in the distribution of the split keys until the concentrations can be matched at the optimum feed tray location if the optimum number of trays is to be obtained very precisely.

It has been general practice to distribute the split key by means of the Fenske equation for total reflux

$$S = \frac{\log\left[\left(\frac{d_{lK}}{w_{lK}}\right)\left(\frac{w_{hK}}{d_{hK}}\right)\right]}{\log \alpha_{lK}} = \frac{\log\left[\left(\frac{d_s}{w_s}\right)\left(\frac{w_{hK}}{d_{hK}}\right)\right]}{\log \alpha_s} \qquad (19)$$

Where S — number of theoretical steps required at total reflux.

The relative volatilities are geometric means of the values taken at the condenser and reboiler.

and to use this distribution for all other reflux ratios. However, no study has been made previousy to determine if this is an optimum distribution.

Thus, we have two points where the distribution of the split key can be determined; total reflux and minimum reflux. Usually these two distributions are considerably different. In an effort to determine if the distribution of split keys for optimum trays at reflux ratios other than minimum or total was intermediate between these two extremes the data in Table 2 was compiled by tray to tray calculations. From this table the following observations can be made:

1) For all practical purposes the distribution of the split keys at total reflux will give an optimum number of trays for all reflux ratios except those which are extremely close to the minimum.
2) Using the distribution of the split key at total reflux, the ratio of the key components at the feed tray matches with fair precision the optimum ratio of the key components as given by the equations of Scheibel and Montross (6).

The above observations may be utilized to obtain reliable product compositions and optimum feed tray locations.

An illustrative example of the calculation of the distribution of a split key at total reflux follows.

Illustrative Example V

Determination of the distribution of a split key component at total reflux.

	Main Feed	d	w
C_1	3	3.0	....
C_2	7	7.0	....
C_3	15	14.7	0.3
C_4	33	*13.0	*20.0
C_5	30	0.2	29.8
C_6	12	....	12.0
	100	37.9	62.1

* Assumed.

Tower pressure = 200 psia. Equilibrium constants from nomograph by Scheibel (5).

	K^{160}	d/K	α_T	K^{205}	wK	α_W	$\alpha_{av} = \sqrt{\alpha_T \alpha_W}$
C_1	16.5	.18	....	....	....	....	.....
C_2	3.7	1.89	....	....	....	....	.....
C_3	1.39	10.58	6.61	3.3	.99	3.93	5.09
C_4	.55	23.6	2.62	1.59	31.8	1.892	2.22
C_5	.21	.95	1.00	.84	25.0	1.00	1.00
C_6	....	....	....	.45	5.4	....	.....
		37.20			63.19		

By equation (19)

$$\frac{\log (14.7)\ (29.8)/(.3)\ (.2)}{\log 5.09} = \frac{\log (d_{c4}/w_{c4})\ (29.8/.2)}{\log 2.22}$$

Then $d_{c4}/w_{c4} = .527$

$w_{c4} = 33/1.527 = 21.6$

$d_{c4} = 33 - 21.6 = 11.4$

Discussion of Parts I and II

For the purpose of obtaining a comparison between the results, at minimum reflux, of the application of the Underwood equations and the Colburn correlation, as presented in this article, to the determination of R_M and d_s, Tables 1A and 1B were prepared.

The results in Table 1B for the Colburn correlation were obtained by neglecting the correction factors in the ψ term. In general, this is permissible without appreciable error if the relative volatility of the light components does

not approach that of the light key component and the relative volatility of the heavy components does not approach that of the heavy key component.

In problem (3) if the correction factors, c, in the ψ term has been used the value of $R_M = 2.23$ and $d_s = 13.56$ would have been obtained. Thus, the minimum reflux value has been improved, but the distribution of the split key has become more divergent from the correct value.

A further discrepancy is noted in problem (6). If, with this system, the relative volatility of the light component is varied from ∞ to 2 the distribution of the split key starts at 11.14 (for $\alpha = \infty$), falls to a minimum of 10.94 at $\alpha = 3.0$ and then rises again to 12.5 at $\alpha = 2.0$. This variation may be followed by the equations of Underwood, but if the Colburn correlation is utilized there is a continuous decrease in d_s as α varies from ∞ to α_{1K}.

The above discrepancies are explained by the fact that Colburn's correlation is no longer accurate when the relative volatility of the light or heavy components approach that of the light key or heavy key component, respectively.

However, this is not a serious limitation since it represents an extreme case and in many cases can be overcome. For example, if in an isomeric separation such that $\alpha_h \rightarrow \alpha_{hK}$, the mols of the heavy key component overhead may be sufficiently large that the heavy component may be considered as a split key which lies outside of the relative volatility limits of the specified key components.

In the depropanizer problem, illustrated by both methods of calculation, the serious limitation of the Underwood equations may be illustrated by the fact that there is a 20 percent deviation between the minimum reflux obtained if the values of α at the fractionating pinch temperature is used and the corresponding value obtained by using α at the temperature of the stripping pinch. By using α_{av}, as in the illustration, there is 7.5 percent difference between the value of R_M obtained and that determined by the Colburn correlation. Thus, for cases in which there is appreciable variation of the relative volatilities, the proper feed tray temperature at which to evaluate the relative volatilities for use in the Underwood equations becomes of primary importance. Since the feed tray temperature must lie between the two pinch temperatures, arithmetic average values of α's taken at the pinch temperatures is recommended.

It may be noted that the application of Underwood's equations to split keys is analagous to calculating different pinch compositions using the Colburn correlation. This suggests that the values of relative volatility should be evaluated at different temperatures for each value of ϕ. Further evidence of this is obtained from the depropanizer problem illustrated. If the same set of average relative volatilities are used by both methods the results are almost precisely identical. However, having obtained R_M and d_s by the Colburn correlations as illustrated, there is no one temperature which permits the checking of R_M and d_s simultaneously when Underwood's equations are used. This check can be obtained only by using different temperatures for the evaluation of each value of ϕ. For example, if the value of ϕ for $\alpha_{1K} > \phi > \alpha_s$ is evaluated at the temperature of the stripping pinch and the value of ϕ for $\alpha_s > \phi > \alpha_{hK}$ is evaluated at the temperature of the fractionating pinch, then $R_M = 0.74$ and $d_s = 14.4$ which is a much better check with the Colburn correlation. No other examples were tried, however, to see if this is a special or general phenomena.

The fact that the distribution of the split key is such that the ratio of the mols of the split key component in the fractionating pinch to that in the stripping pinch lies between the corresponding ratios of the light key component and the heavy key component has been verified by numerous calculations. The assumption that these ratios are precisely linear with respect to $(\alpha - 1)$ has not been verified. However, the assumption of a linear relation represents the average results with good accuracy and permits the use of values in the equations developed which are of a necessity determined in the calculation of the pinch compositions. Further, in most cases a very precise distribution of the split key is not essential for the determination of a good value of minimum reflux. For example, if the calculated mols of the split key overhead is greater than the true value, the calculated values of L_n and D are both greater than the true values and the ratio, $R_M = L_n/D$, tends to remain constant.

A qualitative representation of the optimum mols of

TABLE 2

Tray Requirements and Ratio of Key Components on Feed Tray for Different Distributions of a Split Key

PROBLEM	Mols Feed	α	d	q	R_M	d_s at R_M	d_s at Total Reflux	R	d_s	Trays	η	Calc. η opt.	ref (5) η opt.
(1) lk	30	2.0	28	1.0	1.6	20	24.5	2.0	17.7	∞	...	.85	.94
s	40	1.5	...	...	...	...	...	...	22.0	19.8	.947	...	...
hk	30	1.0	2	...	...	...	...	...	23.0	19.09	.904	...	...
	...	...	...	...	...	...	...	...	24.0	19.00	.855	...	...
	...	...	...	...	...	...	...	...	25.0	19.01	.813	...	...
	...	...	...	...	...	...	...	...	28.7	∞	...	...	...
(2) lk	30	2.0	28	1.0	1.6	20	24.5	4.0	12.43	∞	...	.82	.82
s	40	1.5	...	...	...	...	...	...	20.0	12.0	1.33	...	...
hk	30	1.0	2	...	...	...	...	...	23.0	10.55	1.00	...	...
	...	...	...	...	...	...	...	...	25.0	10.2	.724	...	...
	...	...	...	...	...	...	...	...	27.0	10.7	.502	...	...
	...	...	...	...	...	...	...	...	30.0	12.7	.308	...	...
	...	...	...	...	...	...	...	...	33.0	∞	...	...	...
(3) lk	22.5	2.0	21.0	1.0	1.72	15.38	18.32	4.0	15.4	11.98	1.23	.80	.807
s	30.0	1.5	...	...	...	...	...	...	18.32	10.5	.80	...	...
hk	22.5	1.0	1.5	...	...	...	...	...	21.0	10.9	.45	...	...
h	25.0	0.5	...	...	...	...	...	...	...	...	...	...	...
(4) l	25.0	4.0	25.0	1.0	.978	13.48	18.32	4.0	15.0	9.7	1.91	.81	.82
lk	22.5	2.0	21.0	...	...	...	...	...	18.3	8.65	.81	...	...
s	30.0	1.5	...	...	...	...	...	...	21.0	9.5	.33	...	...
hk	22.5	1.0	1.5	...	...	...	...	...	...	...	...	...	...
(5) c1	3.0	...	3.0	.69	.74	14.04	11.4	1.75	11.4	10.1	.30	...	...
c2	7.0	...	7.0	...	...	...	...	...	14.0	10.1	.25	...	...
c3	15.0	...	14.7	...	...	...	...	...	...	...	...	...	...
c4	33.0	...	...	...	...	...	...	...	...	...	...	...	...
c5	30.0	...	0.2	...	...	...	...	...	...	...	...	...	...
c6	12.0	...	...	...	...	...	...	...	...	...	...	...	...

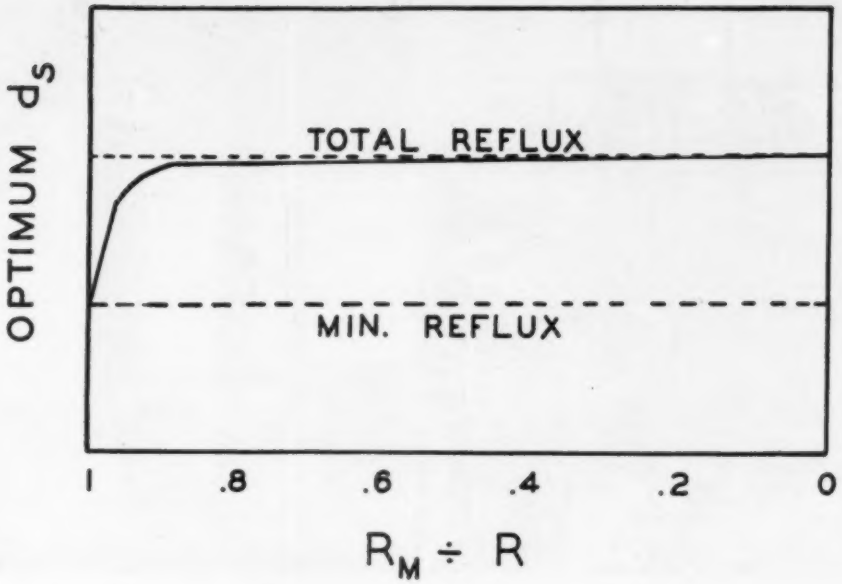


FIGURE 1
Mols of a Split Key Overhead for Minimum Trays.

a split key overhead is shown in Figure 1. It is seen that the optimum mols of the split key component overhead very rapidly approaches the distribution at total reflux as the reflux ratio is increased above the minimum.

It may be noted in the depropanizer problem that the same number of trays was obtained using the distribution for minimum reflux as with the distribution for total reflux. Actually this is not quite correct, but for this problem the distribution of the split key wasn't sufficiently critical to show up in the tray calculations.

Even though Table 2 is not very extensive, the conclusions, which have been made on the basis of the results tabulated, can be accepted without appreciable doubt for the following reasons:

1) Since a minimum number of trays is obtained at total reflux, it is not unreasonable to expect the distribution obtained at total reflux to give a minimum number of trays at other reflux ratios.
2) The problems in Table 2 were selected such that they represent extreme cases; i.e. for most problems encountered the distribution at minimum reflux and total reflux will agree closer than for the problems given in Table 2.

Conclusions

Either the Colburn correlation or Underwood's equations may be used to obtain the distribution of split keys and minimum reflux. For a poor separation of the key components and constant relative volatility the equations of Underwood are less time consuming. For a sharp separation of the key components and constant relative volatility the time required for calculation is about the same for both methods. For cases in which the relative volatility is not constant the Colburn correlation is more reliable.

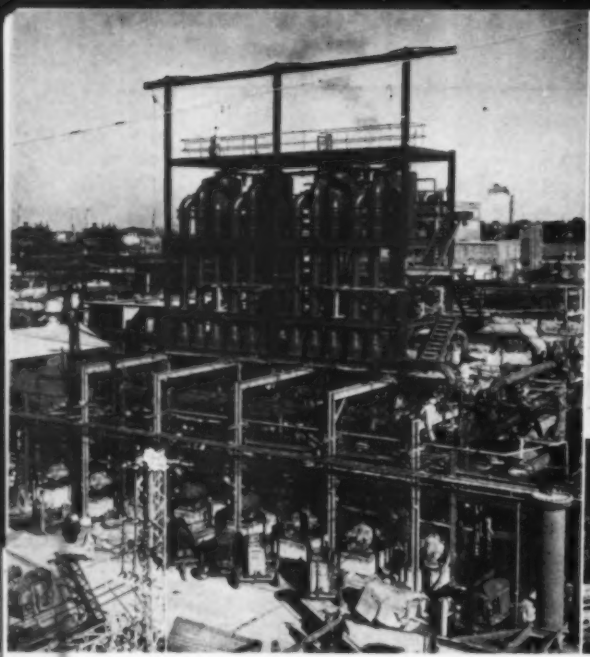
The distribution of split keys at total reflux may be obtained by means of the Fenske equation.

For any reflux ratio between the minimum and total the optimum distribution of split keys is very near the value given by the Fenske equation for total reflux.

BIBLIOGRAPHY

[1] Bailey, R. V., and Coates, J., Petr. Refr., No. 10, **27**, 129 (1948).
[2] Colburn, A. P., Trans. Am. Inst. Chem. Engrs., **37**, 805 (1941).
[3] Fenske, Ind. Eng. Chem., **24**, 482 (1932).
[4] Kuhn, H. W., and Weaver, J. H., "Elementary College Algebra," New York, Macmillan Co., 1st ed., 1937.
[5] Scheibel, E. G., Petr. Refr., **26**, 116 (1947).
[6] Scheibel, E. G., and Montross, C. F., Ind. Eng. Chem., **40**, 1398 (1948).
[7] Underwood, A. J. V., J. Inst. Petroleum, **32**, 598 (1946).
[8] Underwood, A. J. V., J. Inst. Petroleum, **32**, 614 (1946).
[9] Underwood, A. J. V., Chem. Engr. Progress, **44**, 603 (1948).

(End of Part II, and series.)



Left: New refrigeration unit, believed largest of its kind, can cool 24 million gallons water daily by process involving creation of vacuum by use of steam jets. Right: A fourth new plant for ethyl chloride production, shown being constructed here, will be completed next summer.

Ethyl Increasing Plant Capacity

A $40 MILLION expansion program scheduled for 1950 completion at Ehtyl Corporation's plant in Baton Rouge, La., will increase by 40 percent the production facilities there for the manufacture of "Ethyl" antiknock compounds for gasoline.

Included are two additional tetraethyl lead units which will make a total of seven TEL units. Facilities are also being constructed to increase production of sodium, ethyl chloride, and other intermediate chemicals used in producing antiknock compounds.

The entire initial program is about 30 percent complete with some units already finished and others to be completed by spring.

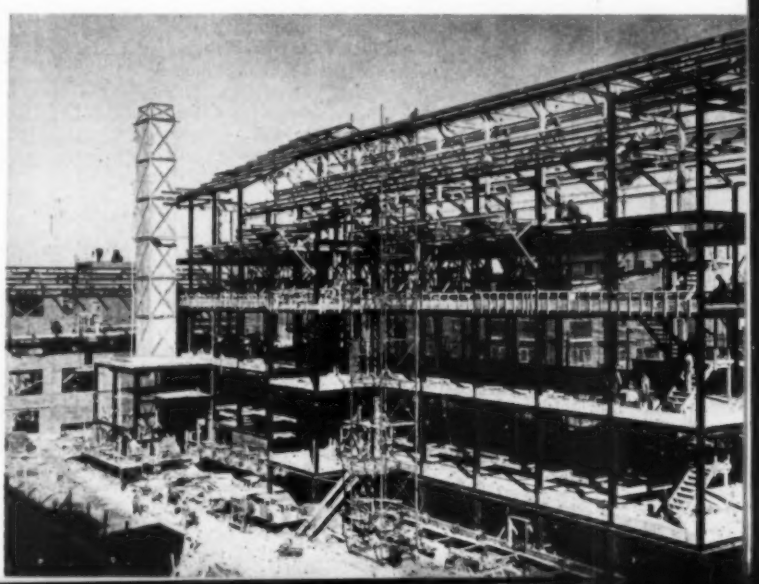
The expansion program represents the largest single expenditure to be made by Ethyl for manufacturing since the plant was first built 12 years ago.

Already in operation is a new three-unit nitrogen plant, completed last October, which has increased the nitrogen output by 100 percent. Additions to Ethyl's extensive water treating system also are going into operation. A new jet refrigeration unit, nearly finished, can chill 24 million gallons of water a day by a unique process involving the creation of a vacuum by use of steam jets.

A new ethyl chloride unit is to be completed this summer and a new plant for the production of ethylene dichloride is being built. Just finished is a new air compressor system for the tetraethyl lead area. Other additions scheduled for early completion included enlarged facilities for melting pig lead, and for recovering lead and ethyl chloride from processed materials. New weight tanks and scales are to be installed in the blender.

Approximately $1,200,000, being spent for employe conveniences, will provide a new medical and personnel building, new change houses, improvements in existing locker and shower rooms, etc.

A new development laboratory and pilot plant is also being added as a part of the expansion program.



Right: Work is being pushed on sixth tetraethyl lead unit which will be in operation before 1949 closes. The seventh will be finished in late 1950.

THE SUCCESS of heat insulation installations used with process equipment is dependent upon many factors. Principal requirements are the choice of materials suitable for specific applications, the adequate design of mechanical details for attachment, expansion provision, and weatherproofing, and the workmanship of the insulation craftsmen. In this article some of these problems of mechanical design are discussed in detail, and especial attention is given to the avoidance of major cracks in insulation through adequate provision for thermal expansion.

Expansion Problems in Heat Insulation of Process Vessels

ELBERT R. SITTON
Insulation Consultant, Houston

IT CAN be truly stated that the expansion of heated vessels and the failure to provide for this expansion when applying insulations has caused more damage to insulating materials than all other causes combined. With operating temperatures staying high, and with vessel sizes becoming larger, this problem of expansion becomes greater.

During the early 20's and before, the standard equipment around refineries were horizontal shell and coke stills with a few small towers. The insulating materials then in general use were natural diatomaceous earth bricks, 85 percent magnesia blocks, asbestos fiber sheets, and occasionally

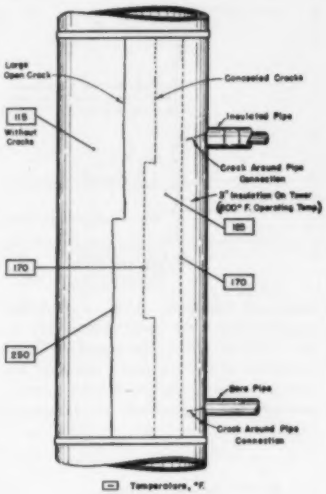


FIGURE 1

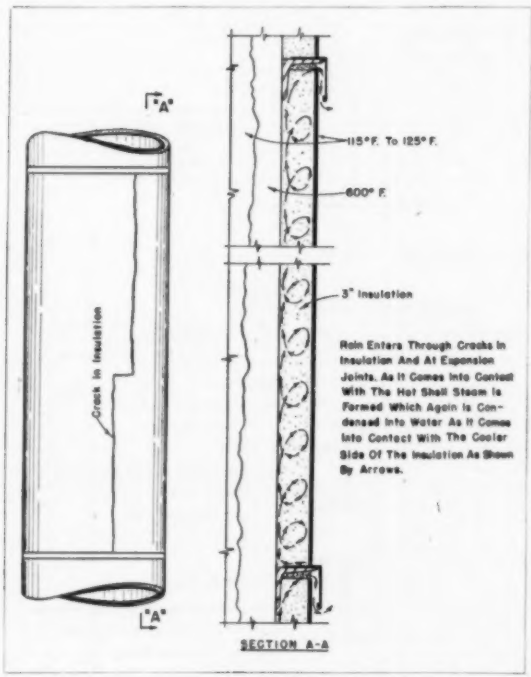

"A"
"A"
Crack in Insulation
115° F. To 125° F.
600° F.
3" Insulation
Rain Enters Through Cracks In Insulation And At Expansion Joints. As It Comes Into Contact With The Hot Shell Steam Is Formed Which Again Is Condensed Into Water As It Comes Into Contact With The Cooler Side Of The Insulation As Shown By Arrows.
SECTION A-A

FIGURE 2

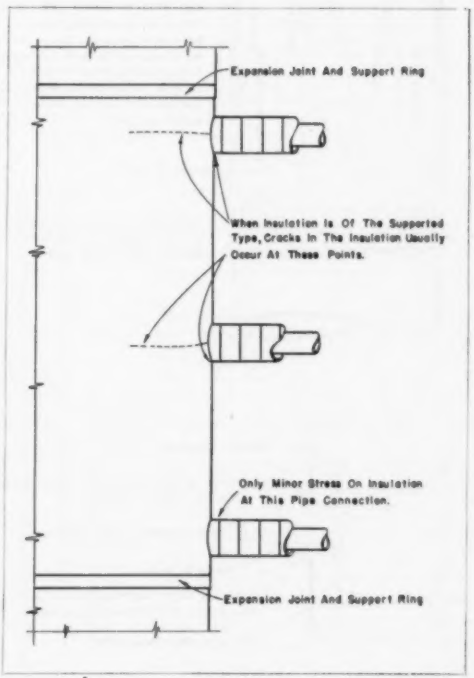

Expansion Joint And Support Ring
When Insulation Is Of The Supported Type, Cracks In The Insulation Usually Occur At These Points.
Only Minor Stress On Insulation At This Pipe Connection.
Expansion Joint And Support Ring

FIGURE 3

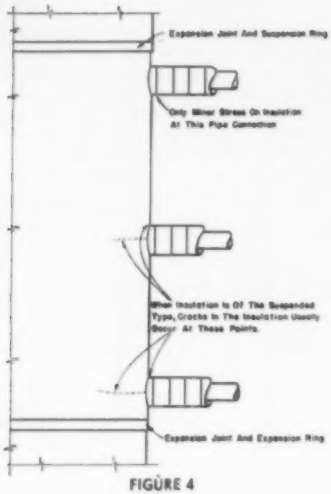

Expansion Joint And Suspension Ring
Only Minor Stress On Insulation At This Pipe Connection
When Insulation Is Of The Suspended Type, Cracks In The Insulation Usually Occur At These Points.
Expansion Joint And Expansion Ring

FIGURE 4

Figure 5

Expansion space to be allowed between tower shell and insulation for various diameters and temperatures.

Dia. of Tower	300° F.	400° F.	500° F.	600° F.	700° F.	800° F.	900° F.	1000° F.
4'	.04"	.06"	.08"	.10"	.12"	.14"	.16"	.18"
5'	.05"	.08"	.10"	.12"	.15"	.17"	.20"	.23"
6'	.06"	.09"	.12"	.15"	.18"	.21"	.24"	.27"
7'	.07"	.11"	.14"	.17"	.21"	.24"	.28"	.32"
8'	.08"	.12"	.16"	.20"	.24"	.28"	.32"	.36"
9'	.09"	.14"	.18"	.22"	.26"	.31"	.36"	.41"
10'	.10"	.15"	.19"	.24"	.29"	.34"	.40"	.45"
11'	.11"	.16"	.21"	.26"	.32"	.38"	.44"	.50"
12'	.12"	.18"	.23"	.29"	.35"	.41"	.48"	.54"
13'	.13"	.20"	.25"	.31"	.38"	.45"	.52"	.59"
14'	.14"	.21"	.27"	.34"	.41"	.48"	.56"	.63"
15'	.15"	.23"	.29"	.36"	.44"	.51"	.60"	.68"
16'	.16"	.24"	.31"	.39"	.47"	.55"	.64"	.72"
17'	.17"	.26"	.33"	.41"	.50"	.58"	.68"	.77"
18'	.18"	.27"	.35"	.43"	.52"	.62"	.73"	.81"
19'	.19"	.28"	.37"	.45"	.55"	.65"	.75"	.86"
20'	.20"	.29"	.38"	.48"	.58"	.68"	.79"	.90"
21'	.21"	.31"	.40"	.50"	.61"	.72"	.83"	.95"
22'	.22"	.32"	.42"	.53"	.64"	.75"	.87"	.99"
23'	.23"	.34"	.44"	.55"	.67"	.79"	.91"	1.04"
24'	.24"	.35"	.46"	.58"	.70"	.82"	.95"	1.08"
25'	.25"	.37"	.48"	.60"	.73"	.85"	.99"	1.13"
26'	.26"	.38"	.50"	.63"	.76"	.89"	1.03"	1.17"
27'	.27"	.39"	.52"	.65"	.78"	.92"	1.07"	1.22"
28'	.28"	.41"	.54"	.67"	.81"	.96"	1.11"	1.26"
29'	.29"	.43"	.56"	.69"	.84"	.99"	1.15"	1.31"
30'	.30"	.44"	.57"	.72"	.87"	1.02"	1.19"	1.35"

When molded blocks are used add 10 percent for shrinkage.

rockwool blankets. Also, monolythic applications were used extensively on the heads of stills. The standard finish consisted of two or more coats of finishing cement reinforced with poultry netting and trowelled to a smooth surface.

Weatherproofing in those days consisted of a coat of asphaltic concrete primer, followed by one or more brush coats of a fibrous enamel compound composed of cut-back asphalt and asbestos fiber. This weatherproofing dried out to a thin skin and failed to hide the numerous cracks that appeared in the insulation beneath. When the vessels were at their top operating temperatures, it was a never-ending job to point up these cracks with a heavier trowelling mixture of cut-back asphalt and asbestos fiber. This work was

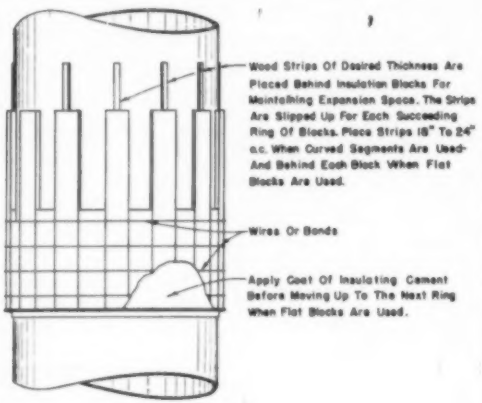

Wood Strips Of Desired Thickness Are Placed Behind Insulation Blocks For Maintaining Expansion Space. The Strips Are Slipped Up For Each Succeeding Ring Of Blocks. Place Strips 18" To 24" o.c. When Curved Segments Are Used And Behind Each Block When Flat Blocks Are Used.
Wires Or Bands
Apply Coat Of Insulating Cement Before Moving Up To The Next Ring When Flat Blocks Are Used.

FIGURE 6

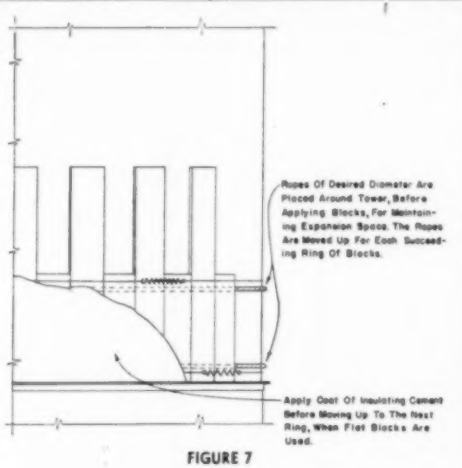

Ropes Of Desired Diameter Are Placed Around Tower, Before Applying Blocks, For Maintaining Expansion Space. The Ropes Are Moved Up For Each Succeeding Ring Of Blocks.
Apply Coat Of Insulating Cement Before Moving Up To The Next Ring, When Flat Blocks Are Used.

FIGURE 7

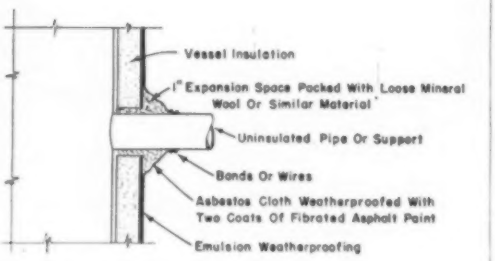

Vessel Insulation
1" Expansion Space Packed With Loose Mineral Wool Or Similar Material
Uninsulated Pipe Or Support
Bands Or Wires
Asbestos Cloth Weatherproofed With Two Coats Of Fibrated Asphalt Paint
Emulsion Weatherproofing

FIGURE 8

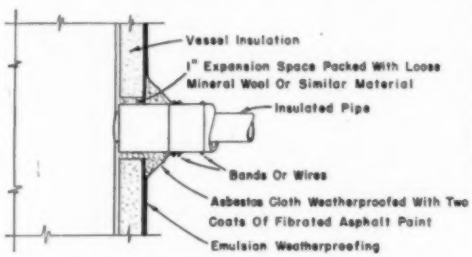
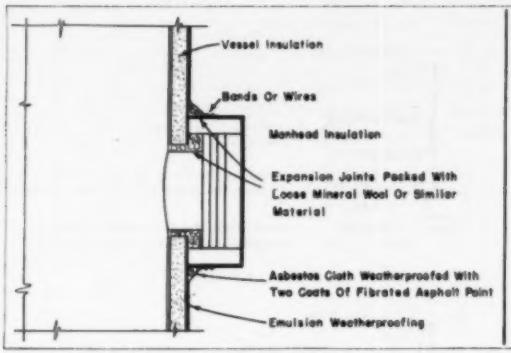
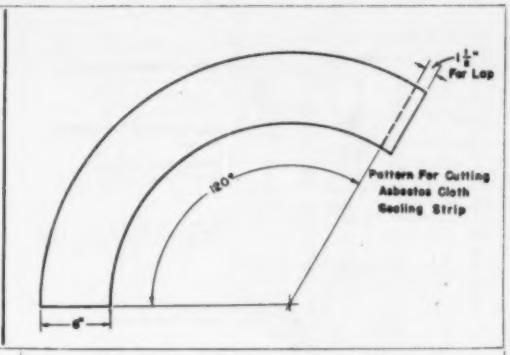

Vessel Insulation
1" Expansion Space Packed With Loose Mineral Wool Or Similar Material
Insulated Pipe
Bands Or Wires
Asbestos Cloth Weatherproofed With Two Coats Of Fibrated Asphalt Paint
Emulsion Weatherproofing

FIGURE 9


Vessel Insulation
Bands Or Wires
Manhead Insulation
Expansion Joints Packed With Loose Mineral Wool Or Similar Material
Asbestos Cloth Weatherproofed With Two Coats Of Fibrated Asphalt Paint
Emulsion Weatherproofing



Above, Left
FIGURE 10

Above, Right
FIGURE 11

promptly annulled when the vessel was cooled down for coke removal or repairs, for severe buckling would appear in the insulation caused by the contraction of the shell. The buckling made other repairs necessary when large sections of the finish became loose and scaled off.

Days of Small Towers

In the middle 20's small-sized towers, as we know them today, became standard equipment. Among the new insulating products of these years we find the emulsified asphalt products which are today manufactured under various trade names, and are applied in heavy trowelled coats over the insulation as a weatherproofing. It is well to bear in mind that this excellent material does not eliminate cracks in the body of the insulation, but does have sufficient "stretch," for a long period to maintain an unbroken coating, provided the individual cracks are not large. It served its purpose well during these days of small towers and vessels.

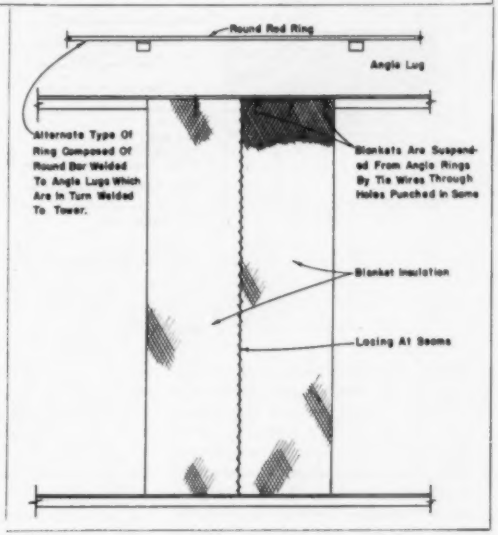

Round Rod Ring
Angle Lug
Alternate Type Of Ring Composed Of Round Bar Welded To Angle Lugs Which Are In Turn Welded To Tower.
Blankets Are Suspended From Angle Rings By Tie Wires Through Holes Punched In Some
Blanket Insulation
Lacing At Seams

FIGURE 13

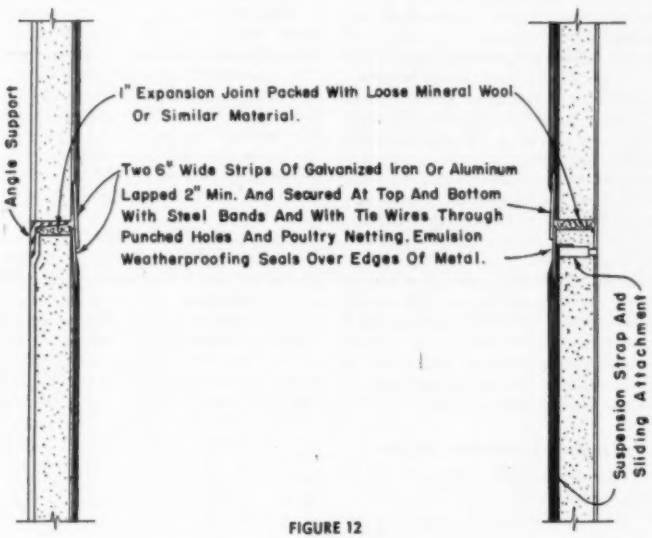

Angle Support
1" Expansion Joint Packed With Loose Mineral Wool Or Similar Material.
Two 6" Wide Strips Of Galvanized Iron Or Aluminum Lapped 2" Min. And Secured At Top And Bottom With Steel Bands And With Tie Wires Through Punched Holes And Poultry Netting. Emulsion Weatherproofing Seals Over Edges Of Metal.
Suspension Strap And Sliding Attachment

FIGURE 12

Today with the trend toward larger and larger towers, the expansion problem becomes more acute. For instance a tower 16 feet in diameter, erected and insulated during 80° F. weather temperature, will expand approximately 3¼ inches in circumference when an operating temperature of 725° F. is reached. This means that if the recommended thickness of 3 inches mineral wool, rock wool or similar type blanket insulation is used and is securely banded in place, the thickness will be reduced to 2½ inches, through the crushing action of the expanding shell. Efficiency is lost through both the increased density of the material and its reduced thickness. If the insulation is the rigid block type, the joints will open for a total of 3¼ inches, exclusive of any shrinkage of the material itself. Due to obstructions such

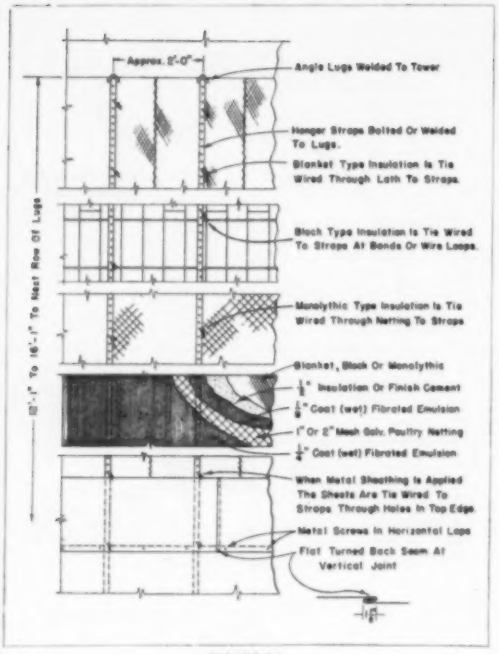

Approx. 2'-0"
Angle Lugs Welded To Tower
Hanger Straps Bolted Or Welded To Lugs.
Blanket Type Insulation Is Tie Wired Through Lath To Straps.
Block Type Insulation Is Tie Wired To Straps At Bands Or Wire Loops.
Monolythic Type Insulation Is Tie Wired Through Netting To Straps
Blanket, Block Or Monolythic
½" Insulation Or Finish Cement
⅛" Coat (wet) Fibrated Emulsion
1" Or 2" Mesh Galv. Poultry Netting
¼" Coat (wet) Fibrated Emulsion
When Metal Sheathing Is Applied The Sheets Are Tie Wired To Straps Through Holes In Top Edge.
Metal Screws In Horizontal Laps
Flat Turned Back Seam At Vertical Joint
12'-1" To 16'-1" To Next Row Of Lugs

FIGURE 14

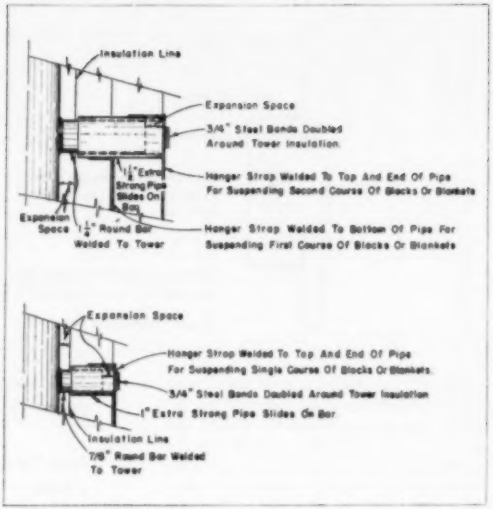

Insulation Line
Expansion Space
3/4" Steel Bands Doubled Around Tower Insulation.
1½" Extra Strong Pipe Slides On Bar
Hanger Strap Welded To Top And End Of Pipe For Suspending Second Course Of Blocks Or Blankets
Expansion Space
1¼" Round Bar Welded To Tower
Hanger Strap Welded To Bottom Of Pipe For Suspending First Course Of Blocks Or Blankets
Expansion Space
Hanger Strap Welded To Top And End Of Pipe For Suspending Single Course Of Blocks Or Blankets.
3/4" Steel Bands Doubled Around Tower Insulation
1" Extra Strong Pipe Slides On Bar
Insulation Line
7/8" Round Bar Welded To Tower

FIGURE 15

as welds, ladder supports, pipe connections, etc., the crack openings are not distributed evenly around the vessel, which results in some being up to $\frac{3}{8}$ inch in width. The sizes of these larger cracks place severe strains on the emulsion weatherproofing. Due to escaping heat through the cracks, the elasticity of the emulsion is lost and visible cracks appear at these points. It is easy to locate the cracks before they appear through the emulsion by taking temperature readings across the surface.

Figure 1 shows how these cracks occur. If the insulation is of the monolythic or mineral wool block types, the joint openings and crushing of the material are about equally divided; and the insulation will have less crushing than for the blanket types and less crack openings than for the rigid block types.

Cracks Are Costly

Considerable heat is lost through cracks and the damage to the equipment and insulation is quite costly. This is caused by rain entering and saturating the insulation. As the water penetrates to the heated shell it becomes steam and rises up through the insulation, thereby setting up an endless chain of alternate condensing and vaporizing until the final exit is made at a much higher point. During this process, corrosion occurs to the steel wire, netting, lath and bands securing the insulation and the vessel itself. In time this corrosion becomes of major importance. Block insulation loses its strength also, causing sagging and buckling.

Figure 2 shows how the vaporizing and condensing action progresses. Insulation on vessels operating at the higher temperatures is the least affected, as the moisture is driven off faster; while the material on vessels operating at the lower temperatures is affected more, due to the greater length of time required (several days in some instances) to drive off the moisture after a hard rain. Insulated vessels that are taken off stream should have all cracks in the insulation thoroughly sealed immediately by competent workmen. Failure to do this has caused heavy damage to many plants made idle after the war's end. The last of these plants inspected by the writer had a condition not unlike one in which the equipment is stored in a trench and kept constantly covered with wet earth, because the insulation had become so thoroughly saturated.

Flashed Expansion Joints

Flashed insulation expansion joints at the insulation support rings are effective in providing for linear expansion of the vessel. However, they fail to take care of the points where pipes and supports welded to the vessel cause cracks in the insulation, as shown in Figures 3 and 4.

Due to their resistance to corrosion the present trend is toward the use of stainless steel and monel bands, wire, and netting, in lieu of the galvanized steel materials. However the use of these will not in itself eliminate cracks in the insulation. It becomes obvious that, in order to obtain the maximum efficiency and life of the insulation it is necessary to prepare correct details and specifications and to have capable supervision while the work progresses.

A few of the writer's ideas in regard to details are shown in this article. First, it is necessary to know how much a tower will expand in circumference, in order to allow the proper space between the shell and insulation for this expansion. Figure 5 is a chart showing the spacing required for various sizes of towers at different temperatures. These are based on an 80° F. weather temperature during the installation of materials.

Figure 6 shows a simple method for obtaining uniform spacing by the use of 48-inch long wooden strips of the correct thickness. As the first ring of blocks is applied around, the strips are placed between the blocks and the shell. After these blocks are secured by wires or bands, the strips are slipped up to accommodate the next ring of blocks; and the operation is repeated for each succeeding ring. If curved block segments are used, the strips are used on from 18- to 24-inch centers; as the segments readily stay in place in relation to each other. If flat blocks

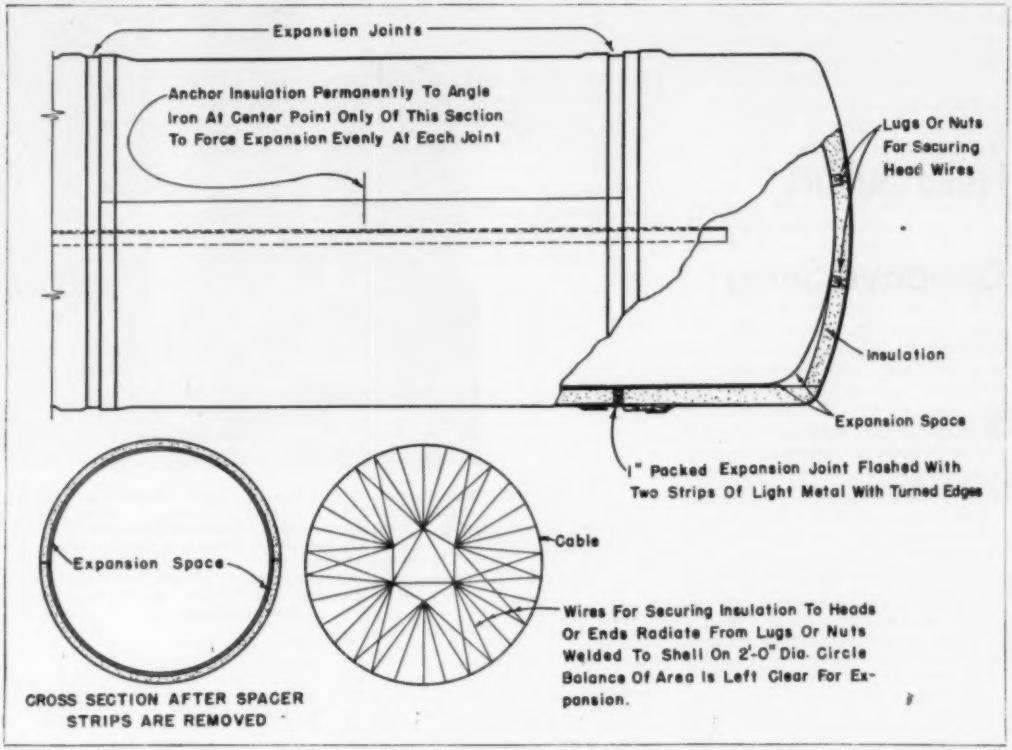

Expansion Joints
Anchor Insulation Permanently To Angle Iron At Center Point Only Of This Section To Force Expansion Evenly At Each Joint
Lugs Or Nuts For Securing Head Wires
Insulation
Expansion Space
1" Packed Expansion Joint Flashed With Two Strips Of Light Metal With Turned Edges
Expansion Space
Cable
Wires For Securing Insulation To Heads Or Ends Radiate From Lugs Or Nuts Welded To Shell On 2'-0" Dia. Circle Balance Of Area Is Left Clear For Expansion.
CROSS SECTION AFTER SPACER STRIPS ARE REMOVED

FIGURE 16

are used, it is necessary to place a strip behind each block and to trowel a coat of insulation cement over the ring of blocks before slipping the strips up for the next ring. Another method is shown in Figure 7, where a rope of the proper diameter is placed twice around the shell and moved up for each succeeding ring of blocks.

Figures 8, 9, 10 and 11 show details for expansion joints around pipes and supports.

Figure 12 shows a simple and practical type of expansion joint at the support rings, or lugs.

Suspended Method

Blanket type insulation gives the best results when suspended from supports welded to the shell. Figure 13 shows an application of this type wherein the tie wires are passed through the blanket lath and around support rings welded to lugs, which are, in turn, welded to the shell. These support rings are placed on 8-foot centers for heavy blankets and on 12-foot centers for light ones. If spacing is greater than these distances, danger of the tie wires tearing through the lath is evident.

Figure 14 shows an improvement of the susupended method, and is suitable for all types of materials. This method is known as "swing-it" (U. S. Patent 2,206,680) and consists of hangar straps extending down from support rings or lugs. The insulating material is secured to these straps along the entire length, which distributes the load evenly. The straps also furnish excellent supports for galvanized iron or aluminum sheathing, if desired. The straps stand away from the shell a distance equal to the thickness of the insulation plus the required expansion space. Angle lug supports are preferred to continuous angle rings, as they reduce both costs and heat losses. The lugs are spaced on approximate 24-inch centers around the tower, and on approximate 16-foot centers vertically. Where the expansion space to be maintained is less than ¼ inch, the lugs are of simple design, with the straps either bolted or welded to them. Where the expansion space is ¼ inch or more, a slip type lug is recommended, such as shown in Figure 15.

For insulating horizontal tanks, as shown in Figure 16, the means of securing the desired expansion space around the tank is the same as for towers; that is, by using spacing strips of wood or spiralled rope.

On tanks 6 feet in diameter and larger, angle irons are welded to each side of the tank and terminate about 18 inches from each end. Stopping of the angles at these points enables the expansion spaces at the ends to be distributed evenly around when the head insulation is fitted. The size of the angle should be ½ inch less than the thickness of blocks or blankets.

* * *

Hello Sulfur!

Goodbye Smog!

Construction details of the Hancock Chemical Company's new plant near Long Beach, Calif., are pointed out to Dr. Louis C. McCabe, director of Los Angeles County's Air Pollution Control District, by W. T. Hancock vice-president of The Hancock Oil Company of California and head of the new organization. Looking on at the left is Hugh J. Gribben, plant manager and supervisor of construction. The plant's No. 1 converter is at the left, the sulfur scrubber is in the center, and the No. 2 converter looms at the right.

FIRST major production of sulfur on the West Coast began near Long Beach, Calif. last month as Hancock Chemical Company, a subsidiary of the Hancock Oil Company of California, started converting hydrogen sulphide from nearby petroleum refineries into elemental sulfur.

The new million-dollar plant plans an original output of 50 tons of sulfur daily with future plans calling for expansion that will double this amount.

"Smog", which plagues the area, will be reduced inasmuch as the sulfur will be produced from gases formerly wasted.

The plant combines a diethanolamine extraction unit with an application of the Simon-Carves process, and will be the only operation of its type outside of three smaller units in Iran and two in Arkansas.

Piped from Refineries

In the first step, extraction units at nearby Texas, Richfield Oil and Union Oil Company refineries absorb hydrogen sulphide from waste gases in an 80-percent aqueous solution of diethanolamine. This solution, piped to the Hancock facilities, is heated in an exchanger and run into a 50 foot stripper with 16 trays operating at 10-20 psi. Liquid taken off at the bottom is circulated through a steam-heated reboiler and sent back to the column at 300° F. Completely stripped, the diethanolamine goes back through the heat exchanger, is cooled, then piped to the refinery units.

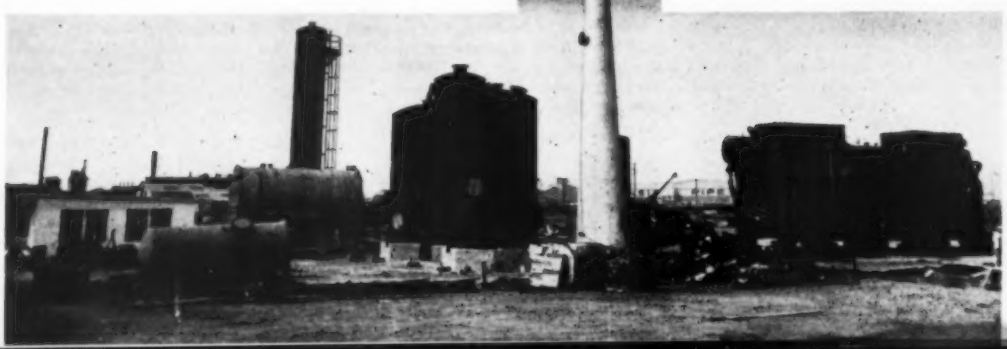
Hydrogen sulphide (containing some carbon dioxide) from the stripper passes through two condensers and into a reflux drum. Condensate from this drum is further stripped in a smaller tower. The amine-free hydrogen sulphide flows into a knock-out drum where the pressure is adjusted to 5-12 psi. Partial combustion of the hydrogen sulphide, using air blown in at 5-12 psi., takes place in a burner to form a limited amount of sulfur dioxide. The small amount of elemental sulfur formed is tapped off from the waste heat boiler, which operates at 3-5 psi. After leaving a cyclone, where sulfur fines are removed, reaction gases pass through the chamber of an auxiliary burner.

Panoramic view of the new Hancock Chemical Company while still under construction shows the stripping tower, converters, sulfur scrubber, stack and boilers.

Final Conversion

Final conversion to liquid elemental sulfur takes place in a catalyst-filled converter. Reaction takes place at about 2-4 psi.; only product in addition to sulphur is water, which pases off as a vapor mingled with unused H_2S and SO_2. These gases are run through a second cyclone auxiliary burner and converter, and into a scrubber, where the final particles of sulfur are removed. Any waste gases are vented from the stack. Liquid sulfur is collected in an underground tank, from which it may be pumped for shipment to local sulphuric acid plants.

Plant manager, and the man who supervised construction, is Hugh J. Gribben. E. B. Badger & Sons Co., Boston, designed the sulfur production unit and built the entire plant. Hancock Chemical Company, headed by W. T. Hancock, plans a second unit as soon as the present one is in full operation. It will utilize H_2S from the nearby refinery of General Petroleum Corporation.



***GENERALIZED** correlations of the isothermal effects of pressure on entropy and enthalpy are presented with comparisons of calculated and observed values of these properties for single and multicomponent hydrocarbon systems. Calculation by other generalized correlations are included in this comparison, which is made for ten pure hydrocarbons and five hydrocarbon mixtures. Where specific entropy and enthalpy data are not available, these generalized methods are recommended. In addition, these charts are convenient for making "first-approximation" calculations in cases where rigorous but tedious methods can be used. These generalizations are not recommended for use in developing Mollier diagrams.*

Applications of Thermodynamics To Hydrocarbon Processing

PART XVI—Effects of Pressure on Enthalpy and Entropy

WAYNE C. EDMISTER
Professor of Chemical Engineering, Carnegie Institute of Technology, Pittsburgh

IN THE previous installment the three methods of determining the isothermal pressure corrections to the enthalpy were discussed. Two of these methods, i.e. experimental adiabatic and isothermal throttling, are applicable only to the enthalpy and not the entropy. The other method, i.e. calculations from P-V-T data, may be used for both entropy and enthalpy. These calculations from P-V-T data may be made graphically from large scale plots of the compressibilities or volume residuals or they may be made analytically from an empirical equation of state fitted to the P-V-T data. With precise P-V-T data the use of an equation of state plus graphical residuals, to get the full benefit of the data, will give the most reliable results.

Where P-V-T data and/or equations of state are available on individual hydrocarbons and their mixtures, this method is the recommended procedure. Several compilations of thermodynamic properties of pure hydrocarbons have been prepared in this way. Where available and applicable tables and charts obtained in this way should be used in engineering calculations because of accuracy, consistency and completeness. Unfortunately, such compilations are not available for enough hydrocarbon systems for hydrocarbon processing calculations.

While the effects of temperature and pressure on the enthalpy may be measured experimentally as well as computed from heat capacity and P-V-T data, the effects of temperature and pressure on the entropy can only be computed. There is no way of measuring the entropy experimentally. This, plus the fact that careful computations from precise data is the most accurate method for the enthalpy anyway, leaves no choice as to the preferred methods of preparing charts and tables of thermodynamic properties for hydrocarbons.

Because of the large number of hydrocarbons involved and the terrific amount of calculation work required, it will probably take several years for the combined efforts of the various investigators in this field to develop anything like a complete collection of reliable charts and tables of thermodynamic properties. In addition to the values of V, H and S for the individual hydrocarbons, methods of combining these values to obtain the values for mixtures are required. This requires more information on enthalpies and entropies of mixing as well as vapor-liquid phase equilibrium.

The ideal gas state properties being compiled by Rossini and collaborators at the National Bureau of Standards give the base values of entropy and enthalpy and also the effects of temperature on these properties for the hydrocarbons, thus establishing the long needed foundation on which compilations giving the effects of pressure and mixing may be developed.

The complex nature of the problem and the lack of better data make it necessary to use shortcut and approximation methods for most hydrocarbon process design calculations. In this installment, generalized correlations for the isothermal effects of pressure on the entropy and enthalpy are presented and compared with similar correlations and precise data for pure hydrocarbons and mixtures. It appears likely that such correlations will have their place among process design tools for many years, even after more precise compilations become available. At that time they will be useful in making preliminary calculations such as may be necessary in trial and error design computations.

Generalized correlations for the isothermal pressure changes in entropy and enthalpy are also derived from P-V-T data by graphical or analytical methods. There are two different procedures for making these derivations. One method is to compute the properties for individual components from specific P-V-T data and then reduce the resulting entropy and enthalpy pressure effects to a generalized correlation. The other method is to develop a generalized correlation of the P-V-T data and to derive the desired generalized thermodynamic properties from the generalized P-V-T correlations, which may be an equation of state, a compressibility factor plot or a reduced volume residual graph. Equations of state and graphical correlations of P-V-T data were discussed in Parts VIII and IX (PETROLEUM REFINER, February, March, 1948). The equations used in deriving the thermodynamic properties from compressibility factors and reduced volume residuals were given in Part XI, as were the computations methods. Tabulated values of the generalized derivatives and integrals of the α_r functions are given in Table 20 in Part XII. From these data the generalized correlations for the effects of pressure on entropy and enthalpy have been developed and are presented in this installment.

Previous Correlations

During the past 15 years several generalized correlations for the isothermal pressure correction to the enthalpy have been developed and published. A few generalized correlations for the entropy pressure correction have been presented.

In 1933 Watson and Nelson[25] first

Table 30

Source of data on isothermal effects of pressure on enthalpy and entropy of hydrocarbon systems.

Hydrocarbon System	Type of Data	Method	Authors	Reference
Methane	Tables of Thermo Props, i.e. H,S, etc.	Calc. from Exp. J-T data and Equation of State	Matthew and Hurd	16
Ethylene	Ditto	Calc. from Equation of State plus graphical Residuals	York and White	30
Ethane	Ditto	Calc. from P-V-T data by Equation of State, plus graphical Integration of PV/RT	Barkelew, Valentine and Hurd	1
Ethane	Values of $-\Delta H$	Calc. from Exp'tl P-V-T data	Sage, Webster and Lacey	23
Ethane	Values of $-\Delta H/Tc$	Calc. from P-V-T data by Eq. of State, plus graphical residuals	York and Weber	29
Propane	Ditto	Ditto	Ditto	29
iso-butane	Table of H, S, etc values	Calc. from Exp'tl. J-T and P-V-T Data	Sage and Lacey	22
n-butane	Ditto	Ditto	Sage, Webster and Lacey	24
n-butane	Tables of Thermo. Props., ie H, S, etc.	Calc. from Equation of State, plus graphical residuals	Prengle, York and Greenhaus	18
n-pentane	Values of $-\Delta H/T$	Exp't. via Joule-Thomson measurements	Kons and Brown	14
n-pentane	Ditto	Exp't. via Isothermal Throttling Calorimeter	Gilliland and Parekh	11
n-heptane	Ditto	Ditto	Ditto	11
iso-octane	Ditto	Ditto	Ditto	11
Benzene	Ditto	Ditto	Gilliland and Lukes	9
Benzene	Tables of Thermo. props., i.e., H, S, etc.	Calc. from Equation of State, extrapolating P-V-T data	Organick and Studhalter	17
Methane-Ethane mixtures	Values of $-\Delta H$	Calc. from Exp'tl. J-T Coefficient and C_p data	Budenholser, Sage and Lacey	5
Methane-propane mixtures	Ditto	Ditto	Budenholser, Botkin, Sage and Lacey	7
Methane-n-butane mixtures	Ditto	Ditto	Budenholser, Sage and Lacey	6
Methane-n-pentane mixtures	Ditto	Graphical calc. from P-V-T data	Sage, Reamer, Olds, and Lacey	19
Two Natural Gases	Values of H	Calc. from Exp'tl. J-T Coefficient and C_p data	Sage, Botkin and Lacey	20

published an enthalpy correction chart giving $-\Delta H/T$ as function of P_r and T_r. This was improved by many contributors that followed.

In 1934, Brown, Lewis & Weber[2] published a generalized chart for the isothermal pressure correction to the enthalpy. This chart was derived from a reduced compressibility plot and was in the form of $-\Delta H/T$ vs. P_r and T_r and was included as an incidental illustration in an article dealing primarily with thermal cracking.

In 1936 Watson and Smith[26] published the first useable generalized correlation for the isothermal effect of pressure on the enthalpy. This correlation was developed from a generalized compressibility factor correlation and the result was a plot of $-\Delta H/T$ vs reduced pressure for lines of constant reduced temperature. This correlation, along with a companion chart for the effect of pressure on the heat capacity, are reproduced on pages 241 and 243 of Dodge's "Chemical Engineering Thermodynamics."[6] In the original article Watson and Smith include a generalized activity coefficient correlation, as well as the compressibility factor plot from which their derivations were made.

Although Watson and Smith did not present a chart for the pressure correction to the entropy this could be computed from the activity coefficient and the pressure correction to the enthalpy by means of an equation derived from the relationship between enthalpy, entropy and free energy, i.e. equation 252 (Part XII) which states

$$\Delta S' = \frac{\Delta H}{T} - R \ln \frac{f}{P} \qquad (252)$$

This is similar to the equation Brown[3] used recently in developing Mollier diagrams for natural gases.

In 1938, this author developed generalized thermodynamic functions from P-V-T data by means of the volume residual in the form of a reduced correlation. The results of this work are tabulated and plotted in Part XII.

In his text *Thermodynamics for Chemical Engineers*, Weber[27] presented on pages 219 and 221, generalized correlations for the isothermal pressure effects on the enthalpy and entropy, the coordinates being $-\Delta H/T$ vs P_r and T_r for the enthalpy and $(\Delta S)_T$ vs P_r and T_r for the entropy. The $-\Delta H/T$ plot is from the earlier article by Brown, Lewis and Weber[2] and is similar to the Watson and Smith[26] chart. The $(\Delta S)_T$ plot was developed from compressibility data. Weber's ΔS chart is not based on ideal gas and hence the values of ΔS are infinite at zero pressure.

In 1940, York and Weber[29] developed a generalized correlation for the isothermal effect of pressure on the enthalpy by correlating, on a reduced basis, similar data developed for individual hydrocarbons, namely: ethane, propane, butane and heptane. Computations were made by an equation of state (the 5 constant Beattie-Bridgeman) plus graphical residuals, as described by York[28], using reliable P-V-T data. The resulting correlation, which gave $(H^* - H)/\phi T_c$ as a function of P_r for lines of constant T_r, was developed by taking propane as the reference substance constructing the generalized plot from these data and then expressing deviations from basic chart by means of the ϕ function which is as follows:

$$\phi = \left(\frac{T_c{}^\circ K}{370}\right)^n$$

Where:

$T_c{}^\circ K$ = Critical temperature of the hydrocarbon in question,

370 = critical temperature of propane

n = unique function of reduced temperature, varying from 0.37 at $T_r = 1.0$ to 0.15 at $T_r = 1.6$

A similar generalized correlation with a correction factor term could have been developed for the entropy but, to this writer's knowledge, this was not done. In addition to not extending the ϕ correction factor to the entropy, the authors did not extend it to reduced temperatures below 1.0. Although these two limitations are drawbacks to the method the results bear out the accuracy in the range applicable.

Hougen and Watson[12] developed $-\Delta H/T_c$ and $-\Delta S'$ charts from the previously described work. The $-\Delta H/T_c$ plot was developed by using the data of York and Weber[29] and the writer (Table 20, Part XII). In this correlation, the authors include the York-Weber ϕ factor correction idea, using *n*-pentane as the reference substance. For the entropy, Hougen and Watson developed a generalized correlation giving the residual entropy as a function of reduced pressure and temperature using their previously developed $-\Delta H/T_c$ correlation and a compressibility factor plot. No ϕ factor corrections were included in the entropy correlation of Hougen and Watson. The equation used is

$$-\Delta S' = R\int_{P_r}^{\circ} (1 - Z)\, d \ln P_r + \left(\frac{-\Delta H}{T_c}\right)\frac{1}{T_r} \qquad (308)$$

In this way the residual entropy is dependent upon two previous correlations, namely: the compressibility factor and the pressure correction to enthalpy. Since these two are from separate sources there is a good chance for inconsistencies. However, the method is correct and the charts are an improvement over previous charts.

Reference States

Before using the proposed new enthalpy and entropy correlations, the reference state should be clearly understood. This is of particular im-

portance because of the different datum states that have been used in the past. The reference state question for the entropy is particularly confusing because of the different states used by Weber and by Hougen and Watson, sometimes for the same things.

Rossini uses the superscript zero (C_p°, S°, H°, etc.) to denote the value of the property at the ideal gas state of unit fugacity. Since this has been adopted by the Bureau of Standards and others it may be concluded that this notation is a universal standard. To distinguish from zero pressure properties, an asterisk will be used for the latter. For practical purposes two reference states are equivalent, as will be demonstrated below.

The reference state for the generalized isothermal pressure correction correlations, $\Delta H/T_c$ vs T_r and P_r and $-\Delta S'$ vs T_r and P_r, is the ideal gas state. This may be zero pressure for the enthalpy, but it must be more carefully defined for the entropy. It is convenient to consider $(S + R \ln P)$ as one term and to define H^* and $(S + R \ln P)^*$ as the values of the functions at zero pressure. The terms H° and $(S + R \ln P)^\circ$ are defined as the values obtained by an isothermal integration from zero pressure to atmospheric (or other low reference pressure) pressure by using $PV = RT$ as the P-V-T relationship. By means of these definitions for entropy and enthalpy, the significance of the ideal gas state will be demonstrated.

The isothermal pressure correction to the enthalpy obtained by integrating equation 240 at constant temperature, is

$$H - H^* = \int_0^P \left[T \left(\frac{\partial \alpha}{\partial T} \right)_P - \alpha \right] dp \qquad (309)$$

When $PV = RT$, as is the case assumed, the value of the integral on the right of the equal sign is zero, giving

$$H^\circ = H^* \qquad (310)$$

Thus the enthalpies at the ideal gas state and at zero pressure are equal.

The isothermal pressure correction to the entropy, obtained by integrating equation 234 at constant temperature, is

$$(S + R \ln P) - (S + R \ln P)^* = \int_0^P \left(\frac{\partial \alpha}{\partial T} \right)_P dP \qquad (311)$$

When $PV = RT$, as in the assumed situation, the integral on the right of the equal sign is zero, giving

$$(S + R \ln P)^\circ = (S + R \ln P)^* \qquad (312)$$

At one atmosphere the R ln P term is zero making

$$S^* = (S + R \ln P)^* \qquad (313)$$

Thus, the entropy at the ideal gas state equals the value of $(S + R \ln P)$ at zero pressure, which justifies writing

$$(S + R \ln P)_P = S^* + \int_0^P \left(\frac{\partial \alpha}{\partial T} \right)_P dP \qquad (314)$$

This equation may be written as follows, this equation being given in Table 16 Part XII

$$S = S^* - R \ln P + \Delta S' \qquad (315)$$

Where: $\Delta S' = \dfrac{P_c \alpha_c}{T_c} \displaystyle\int_0^{P_r} \left(\frac{\partial \alpha_r}{\partial T_r} \right)_{P_r} dP_r$

This residual entropy correction function is frequently written

$$-\Delta S' = (S^\circ - S - R \ln P) \qquad (316)$$

This is the same entropy correction function that Hougen and Watson[12] presented. Another entropy correction function is presented by Weber.[27] The relationship between the two functions is shown below.

Between any two pressures, at constant temperature, the difference in entropy from equation (316) is

$$(\Delta S)_T = (S^\circ_2 - S_2 - R \ln P_2) - (S^\circ_1 - S_1 - R \ln P_1)$$

$$(\Delta S)_T = (S^\circ - S)_2 - (S^\circ - S)_1 - R \ln \frac{P_2}{P_1} \qquad (317)$$

This is apparently the function Weber[27] correlated. The $R \ln \frac{P_2}{P_1}$ term becomes infinite when $P_1 = 0$, thus giving infinite values for $-(\Delta S)_T$. It would be difficult to establish a generalized reference state for this method of calculating entropy.

The use of equations 315 and 316 are more convenient and logical from the standpoint of the reference state. In applying these equations the R ln P term enters into the evaluation of the datum entropy S° and also into the calculation of values of S. Any units of P (atmospheres, psia, P_r, etc.) may be used as long as the same units are used in establishing S° as in calculating S.

Also most any low pressure (1 psia; 10 psia, or 1 atm.) may be used as the datum, providing S° is evaluated accordingly. In compiling thermodynamic properties of methane and ethane, Hurd and collaborators[1, 16] used 1 psia. On the other hand York and collaborators[18, 30] used 1 atm. for ethylene and *n*-butane. These datum pressures are quite different and yet changes in the entropy values are correct for each hydrocarbon.

Such a difference in reference states would not be advisable in a complete and consistent compilation of thermodynamic properties of hydrocarbons and their mixtures. The ultimate probably will be tabulations giving absolute entropies and enthalpies, which values will include the entropies and enthalpies of formation. The compilations of Rossini et al for the ideal gas state are a start in this direction. The datum used by York et al is that standardized by Rossini.

Absolute enthalpies and entropies could be obtained for any hydrocarbon by adding the proper values of S and H to the tabulated values for liquid and vapor (i.e. above an arbitrary datum point and a function of temperature and pressure). With entropies and enthalpies referred to the elements at absolute zero reaction heat balances and equilibrium calculations could be easily made. Hydrocarbon tabulations may eventually come to this. The writer has used enthalpy plots of this type and found them most convenient.

Proposed New Correlations

Figures 48 and 49 are new generalized correlations for the isothermal effects of pressure changes on the entropy and enthalpy. These charts were developed from the information given in Part XII (PETROLEUM REFINER, June, 1948). Figure 48 is similar to Figure 106 in Hougen and Watson[12] but developed differently as described above. Likewise Figure 49 is similar to Hougen and Watson's Figure 107, but was likewise developed differently besides having a different entropy scale. The similarities and differences between these two sets of charts will be brought out in more detail below.

The generalized equation for the isothermal pressure correction to the enthalpy is given in Table 16 (Part XII). In Table 20 and in Figure 34 values of $-\Delta H/k_3 (k_3 = P_c \alpha_c)$ are given as functions of P_r and T_r. It has been shown that $k_2 = 1.44\, T_c$ (because $k_2 = \frac{P_c \alpha_c}{T_c}$ $= 1.44$ and $k_3 = k_2 T_c$). With this simplification the generalized equation for the enthalpy becomes

$$\frac{-\Delta H}{T_c} = 1.44 \int_0^{P_r} \left[\alpha_r - T_r \left(\frac{\partial \alpha_r}{\partial T_r} \right)_{P_r} \right] dP_r \qquad (318)$$

The function $\frac{-\Delta H}{T_c}$ was evaluated from Table 20 by multiplying values of $\frac{-\Delta H}{k_3}$ by 1.44. From these data Figure 48 was constructed. In preparing Figure 48, the temperature and

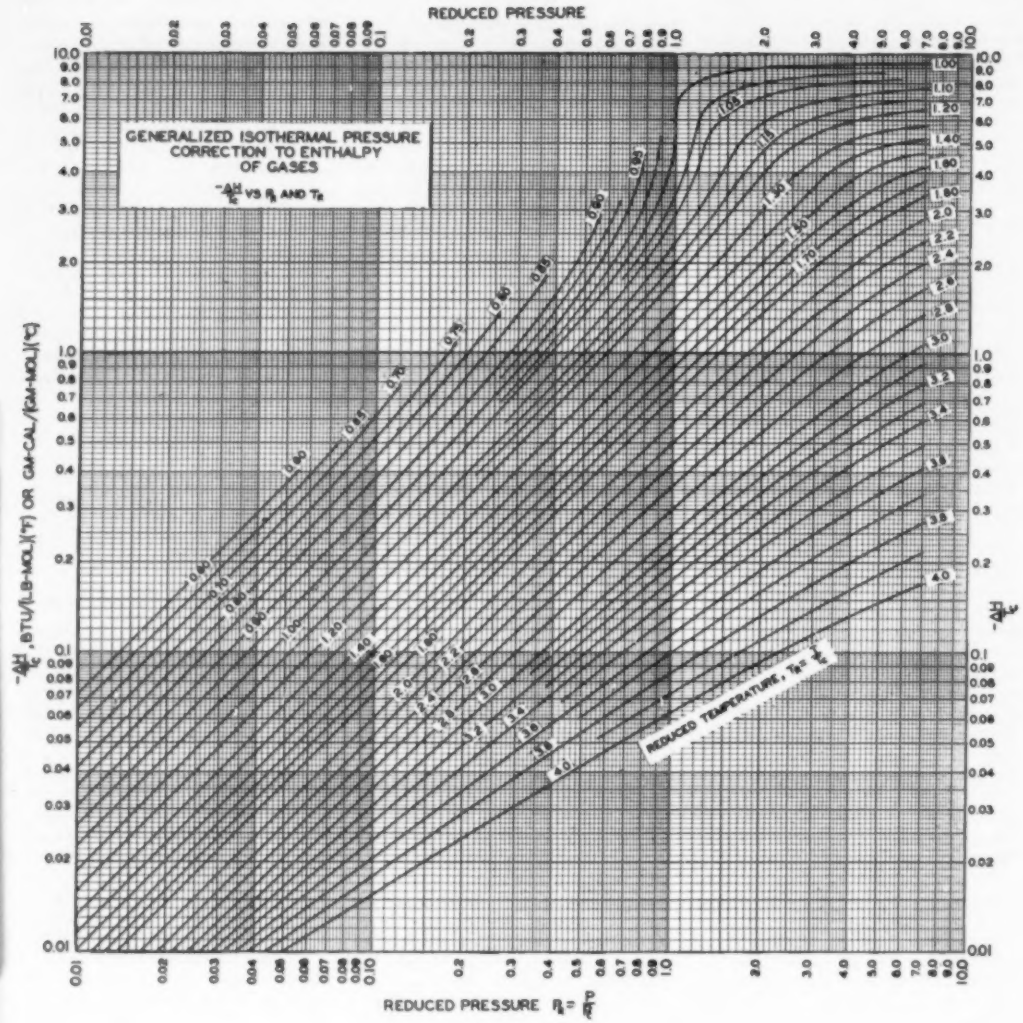

REDUCED PRESSURE
GENERALIZED ISOTHERMAL PRESSURE CORRECTION TO ENTHALPY OF GASES
$-\frac{\Delta H}{T_c}$ VS P_r AND T_r
$-\frac{\Delta H}{T_c}$, BTU/(LB-MOL)(°F) OR GM-CAL/(GM-MOL)(°K)
REDUCED TEMPERATURE, $T_R = \frac{T}{T_c}$
REDUCED PRESSURE $P_R = \frac{P}{P_c}$

FIGURE 48

pressure ranges were extended to increase the usefulness of this generalized correlation.

In constructing Figure 48 from Table 20 and Figure 34, the characterizing constant k_3 has been eliminated with very little sacrifice in accuracy and with a great increase in convenience of use. It appears that this simplification is justified for most all process engineering calculations. If greater precision is required, Figure 48 could be used with a characterizing correction term, which could be a constant for each hydrocarbon (or mixture) or it could be a variable factor for each substance. The first might be the ratio $(P_c a_c/1.44)$ or some empirical correction factor. The other might be similar to the York and Weber ϕ factor correction term. At the present such a correlation could not be prepared. A more complete and thorough study of the generalized thermodynamic properties is necessary before a correlation more refined than Figure 48 could be developed.

At this point it is of interest to note that Figure 48 could have been developed from a compressibility factor correlation just as well. For such a derivation the equation would be

$$\frac{-\Delta H}{T_c} = R \int_0^{P_r} \frac{T_r^2}{P_r} \left(\frac{\partial Z}{\partial T_r}\right)_{P_r} dP_r \qquad (319)$$

where: R = gas constant in proper units, and
Z = PV/RT = function of P_r and T_r.

Equation 319 gives $-\Delta H/T_c$ as a unique function of T_r and P_r with no characterizing variable, such as the $k_3 = P_c a_c$ that was replaced by 1.44 T_c in deriving equation 318.

Equations 318 and 319 give the same enthalpy function. The general-

ized form of equation 319 seems to justify the simplifications that were made in deriving equation 318 particularly in view of the conclusions reached by Su (Part IX) regarding the validity of the compressibility factor plot.

In earlier[2, 25, 26] work on this subject the isothermal pressure correction to the enthalpy was correlated as $-\Delta H/T$ (actually the ratio read $M\Delta H/T$ but this has been changed to be consistent with present nomenclature), rather than $-\Delta H/T_c$. If either is a generalized function of P_r and T_r, it follows that the other is likewise a generalized function, because

$$\left(\frac{-\Delta H}{T}\right)^{T_r} = \left(\frac{-\Delta H}{T_c}\right) \quad (320)$$

As mentioned above, Weber uses $\frac{-\Delta H}{T}$ in his text while Hougen and Watson employ $-\Delta H/T_c$ in their text. From equation 320 it can be seen that both are equivalent. Later, comparisons will be made between Figure 48 and the Hougen and Watson correlation (their Figure 106).

Values of $\frac{-\Delta S'}{k_2}$ are presented as a function of P_r and T_r in Table 20 and Figure 33 (Part XII). Using the value of $k_2 = \frac{p_c a_c}{T_c} = 1.44$ permits preparing a more convenient graph for the residual entropy. This new generalized correlation is given as Figure 49. In preparing Figure 49, the temperature and pressure ranges were extended as they were for Figure 48. Figure 49 is similar to Hougen and Watson's residual entropy correlation, Figure 107, except for the notations on the entropy scales. Otherwise, the two graphs are alike, giving numerical values that are in substantial agreement as well as a parameter of curves that have the same appearance. As mentioned earlier, Hougen and Watson's $-\Delta S'$ chart was derived from a generalized derivation, rather than directly from a P-V-T correlation.

Figures 48 and 49 are consistent because they were both derived directly from the same generalized P-V-T data correlation, namely the correlation. For this reason, as well as the better accuracy, Figures 48 and 49 are recommended in preference to the similar correlations of Hougen and Watson.

Illustrating Problem

The application of Figures 48 and 49 will be illustrated by the solution of a simple example.

Problem:

Propane is expanded from 450 psia. and 200° F. to a final pressure of 200 psia. along a reversible adiabatic (constant entropy) path. Find the final temperature and the enthalpy change. (Note the similarity with problem solved in previous installment.)

Solution for Final Temperature:

Since the path is isentropic the solution is found by assuming a final temperature and then calculating the changes in entropy with temperature and pressure. For the correct final temperature, the change in S with temperature is equal to and of opposite sign to the change in S with pressure. This calculation will be made using an average or mean heat capacity for the constant pressure path. The two paths are a) Expand at constant temperature of 200° F. and from 450 psia. to 200 psia. and b) Cool at constant pressure of 200 psia. from 200° F. to the final temperature. The entropy change along path "a" must equal the entropy change for path "b," and be of opposite sign, thus determining the final temperature. Expressed mathematically

$$C_{P_{mean}} \ln \frac{T_1}{T_2} = R \ln \frac{P_1}{P_2} - \left[(-\Delta S)_1 - (-\Delta S)_2 \right] \quad (321)$$

The left side of equation 321 is for path "b" while the right side is for path "a". The computations for these two paths follow:

Path "a"

at 200° F, $T_r = \frac{200 + 460}{666} = 0.99$

at 450 psia., $P_r = \frac{450}{618} = 0.73$

at 200 psia., $P_r = \frac{200}{618} = 0.325$

From Figure 49

$-\Delta S_1 = 1.45$ Btu./ (lb. mol) (°R)
$-\Delta S_2 = 0.58$ Btu./ (lb. mol) (°R)

substituting in equation 321 gives

$$C_{P_{mean}} \ln \frac{T_1}{T_2} = R \ln \frac{450}{200} - [1.45 - 0.58] = 1.61 - 0.87$$

$$C_{P_{mean}} \ln \frac{T_1}{T_2} = 0.74 \quad (321a)$$

Path "b"

Assume a final temperature of 125° F. for purposes of evaluating $C_{P_{mean}}$.

at 125°F., $T_r = \frac{125 + 460}{666} = 0.878$

CONDITIONS		C_{p_0}	ΔC_p	$C_p = C_{p_0} + \Delta C_p$
T°F.	P. psia.	Fig. 37	Fig. 38	
200	200	21.0	2.7	23.7
125	200	19.0	5.7	24.7
			$C_{p\ mean}$ =	24.2

For this path the use of a mean heat capacity involves very little error, as can be seen by the values of C_p at initial and final conditions.

Substituting in equation 321a gives

$$24.2 \ln \frac{660}{T_2} = 0.74$$

Solving for t_2 gives

$$t_2 = 585 - 460 = 125°F.$$

This checks the assumed value used in finding the mean heat capacity.

Solution for Enthalpy change:

The change in enthalpy is equal to the algebraic sum of changes with temperature and pressure, or

$$H_2 - H_1 = C_{P_{mean}} (T_2 - T_1) - T_c \left[\left(\frac{-\Delta H}{T_c}\right)_2 - \left(\frac{-\Delta H}{T_c}\right)_1 \right] \quad (322)$$

From Figure 48

$$\left(\frac{-\Delta H}{T_c}\right)_1 = 2.35 \text{ Btu./(lb. mol) (°R)}$$

$$\left(\frac{-\Delta H}{T_c}\right)_2 = 0.83 \text{ Btu./(lb. mol) (°R)}$$

Substituting in equation 322

$H_2 - H_1 = 24.2\ (125 - 200) -$

$666\ [0.83 - 2.35]$

$H_2 - H_1 = -1815 + 1012 =$
-802 But./lb. mol.

$H_2 - H_1 = -18.2$ Btu./lb.

In expanding from 450 psia. and 200° F. along an isentropic line to a final pressure of 200 psia., the propane cools to 125° F. with an 18.2 Btu./lb. decrease in enthalpy, which is the theoretically maximum work that could be obtained in an expander with this change in conditions for propane.

Enthalpy-Entropy Data for Testing Correlations

The generalized correlations presented in this installment as Figures 48 and 49 have been developed without the use of any of the available compilations of thermodynamic properties for the hydrocarbons. It is of interest to test these correlations with all available observed data and rigorously computed values to find the accuracy and limitations of the proposed new correlations.

In making such a comparison it is best to use only data of unquestionable accuracy as the standard of perfection. Selecting data of this kind and justifying the choice are beyond the scope of this series. Accordingly comparisons will be presented that include the available data and the other correlations as well. The results of these comparisons will be indicative if not conclusive. A long critical study is required to do this job completely.

With this objective it was necessary

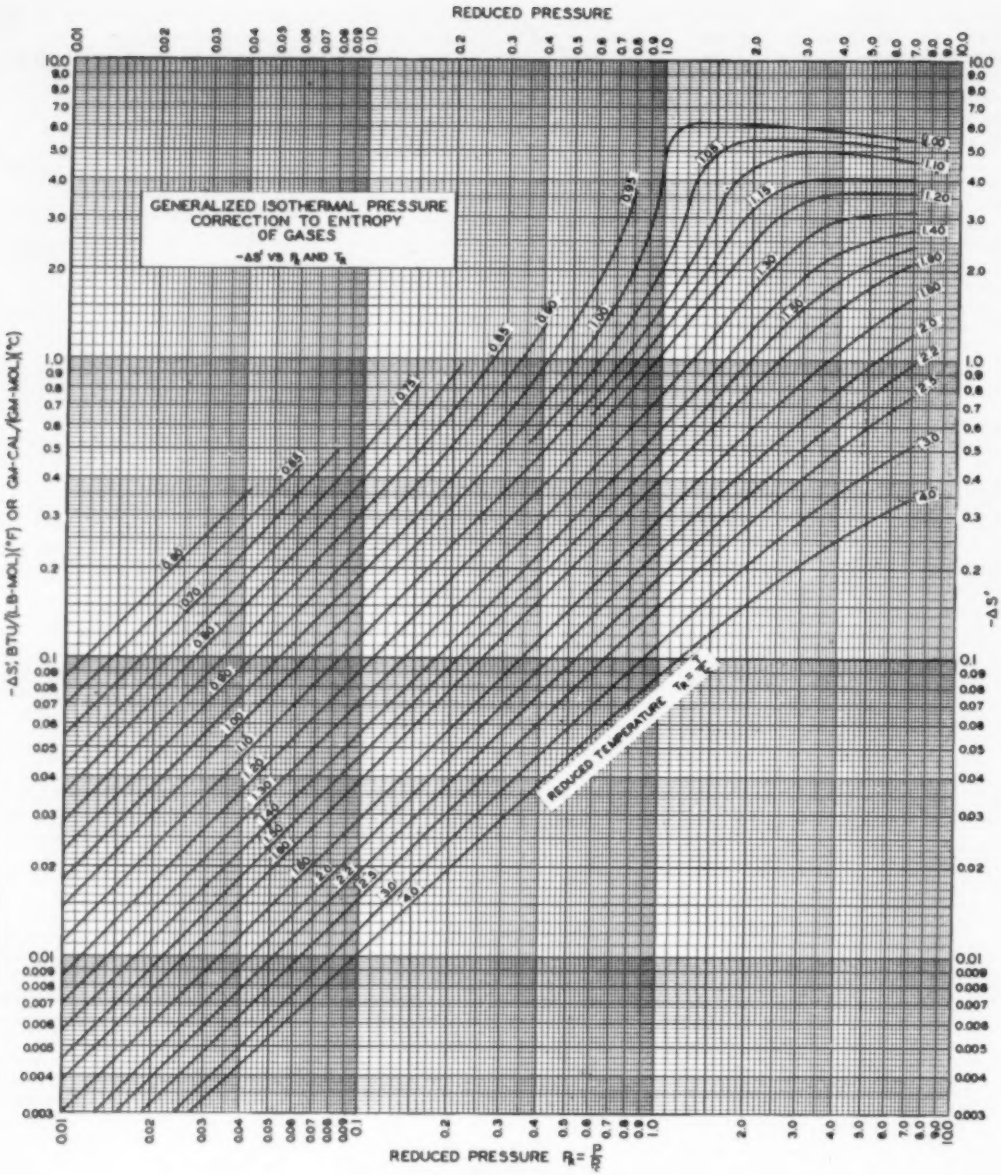

REDUCED PRESSURE
GENERALIZED ISOTHERMAL PRESSURE CORRECTION TO ENTROPY OF GASES
$-\Delta S'$ VS P_R AND T_R
$-\Delta S'$, BTU/(LB-MOL)(°F) OR GM-CAL/(GM-MOL)(°C)
REDUCED TEMPERATURE $T_R = \frac{T}{T_c}$
REDUCED PRESSURE $P_R = \frac{P}{P_c}$
$-\Delta S'$

FIGURE 49

to find the available data on the isothermal effect of pressure on entropy and enthalpy of hydrocarbons. Data of this kind are available in the technical literature for ten pure hydrocarbons and six hydrocarbon mixtures. For six of these pure compounds both enthalpy and entropy data are available. In Table 30 the sources and types of data are shown along with authors and reference numbers.

The isothermal pressure effect on entropy is always calculated from P-V-T data by graphical or equation of state methods. For the enthalpy there are the following methods of finding the effect of pressure:

a) Experimental measurements in an isothermal throttling calorimeter, as employed by Gilliland et al (9, 10 and 11) for benzene, pentane, heptane, and isooctane;
b) Calculations from experimental Joule-Thomson effect data as employed by Sage, Lacey et al (5, 6, 7, 20, 22 and 24) for light hydrocarbon systems, both single and multicomponent systems;
c) Calculations from P-V-T data by

an equation of state or by graphical methods;

d) Calculation with equation of state plus graphical residuals;

e) Calculations from both P-V-T data and experimental Joule-Thomson coefficient data; and

f) Preparation of complete tables and graphs of thermodynamic properties, using any one or more of the above methods.

The compilation of complete tables and charts was listed separately because it should be the most reliable and consistent as there are many ways of cross checking the work. Unfortunately, this is not always the case. Sometimes the basic data is not of high quality, leaving uncertainties about the resulting tabulations. Sometimes the data is extended further than is justified, thus making the higher regions questionable. Sometimes Mollier diagrams are prepared from generalized correlations, as, for example, the series on natural gases by Brown.[3] These charts are useful in natural gas calculations but they are of little value in checking new generalized correlations.

In general, the position in making these comparisons is that all data developed for specific hydrocarbon systems, by any method whatever, will be considered as *observed* data. This is not doing justice to some of the better and more complete compilations, but under the circumstances, this is all that can be done.

For some hydrocarbons more than one source of data are available. Where only one set of data exists, as is the case of methane, ethlyene, etc., there is no choice as to which data should be considered the *observed*. For ethane there are three sources of ΔH and one of ΔS data, as indicated in Table 30. For propane only one is indicated although several Mollier diagrams have appeared during recent years (Sage and Lacey, Stearns and George, etc.). These other sources were not suitable because of difficulty in reading values of H and S with sufficient accuracy to calculate ΔH and ΔS values that would be representative.

There are two sources of ΔH and ΔS values for *n*-butane, and both are used in the comparisons. There are two sources of ΔH values for *n*-pentane and these are likewise used. For benzene two sources of ΔH and one of ΔS are available.

Binary mixtures of methane with ethane, propane, butane and pentane have been studied and values of ΔH computed. Likewise two natural gases

Table 31

Evaluation of generalized correlations for isothermal effects of pressure on enthalpy and entropy of methane. (Source of observed values: Matthews and Hurd.[14])

Temperature, °F.	Pressure Psia.	−ΔH, Btu./Lb.			−ΔS', Btu./Lb. °R		
		Obs.[16]	Fig. 48	H. & W.[12]	Obs.[16]	Fig. 49	H. & W.[12]
0	100	3.5	3.9	4.4	0.0043	0.0061	0.0081
	400	16.6	15.4	18.3	0.0224	0.0249	0.0282
	800	34.8	35.9	36.6	0.0496	0.0529	0.0575
	1000	44.7	42.0	47.4	0.0646	0.0677	0.0750
	1500	70.9	68.7	71.0	0.103	0.1072	0.112
200	100	1.9	2.0	2.4	0.0013	0.0023	.....
	400	7.9	8.1	9.3	0.0076	0.0093	0.0122
	800	15.5	16.0	17.9	0.0163	0.0194	0.0231
	1000	19.2	19.7	21.5	0.0204	0.0233	0.0275
	1500	27.7	28.1	30.1	0.0326	0.0335	0.0387
400	400	4.7	4.9	5.7	0.0034	0.0055	0.0077
	800	9.5	9.6	10.4	0.0078	0.0107	0.0137
	1000	11.9	11.7	12.7	0.0098	0.0133	0.0166
	1500	17.2	16.5	16.3	0.0165	0.0191	0.0231

Table 32

Evaluation of generalized correlations for isothermal effects of pressure on enthalpy and entropy of ethylene. (Source of observed values: York & White.[30])

Temperature, °F.	Pressure Atm.	−ΔH, Btu./Lb.			−ΔS', Btu./Lb., °R		
		Obs.[30]	Fig. 48	H. & W.[12]	Obs.[30]	Fig. 49	H. & W.[12]
60	20	16.4	16.0	17.5	0.0228	0.028	0.0254
	50	59.6	63.6	65.5	0.092	0.096	0.125
	100	134.2	148.3	153	0.200	0.203	0.247
	200	139.2	156.3	162	0.182	0.197	0.236
200	20	9.1	8.9	10.6	0.0098	0.010	0.012
	50	25.1	24.0	27.4	0.031	0.027	0.030
	100	55.6	52.3	57.0	0.063	0.061	0.065
	200	96.3	92.2	101	0.108	0.106	0.114
300	20	6.7	6.5	8.1	0.0058	0.006	0.008
	50	17.9	17.8	20.2	0.023	0.018	0.019
	100	37.4	37.6	39.5	0.038	0.036	0.039
	200	69.1	69.5	71.3	0.069	0.071	0.073
500	20	3.1	4.8	5.8	0.0038	0.0039	0.0049
	50	10.5	11.6	12.7	0.009	0.0059	0.0116
	100	20.9	23.3	23.6	0.018	0.0204	0.0211
	200	38.7	41.0	41.0	0.033	0.0329	0.0346

Table 33

Evaluation of generalized correlations for isothermal effects of pressure on enthalpy and entropy of ethane. (Source of observed values: Barkelew, Valentine and Hurd.[1])

Temperature, °F.	Pressure Psia.	−ΔH, Btu./Lb.			−ΔS', Btu./Lb. °R		
		Obs.[1]	Fig. 48	H. & W.[12]	Obs.[1]	Fig. 49	H. & W.[12]
100	100	5.4	5.0	5.9	0.0069	0.0063	0.0074
	300	18.6	18.3	19.2	0.0237	0.0232	0.0240
	600	47.3	47.2	50.3	0.0604	0.0618	0.063
	1000	131.5	137.2	139.0	0.1685	0.1857	0.207
	1250	137.5	148.6	152	0.1975	0.1930	0.217
	1500	141.1	154.2	155	0.1979	0.1934	0.220
300	100	2.6	2.7	3.3	0.0028	0.0028	0.0038
	300	8.5	8.9	10.2	0.0082	0.0064	0.0099
	600	18.1	18.6	21.0	0.0159	0.0170	0.020
	1000	31.3	31.8	34.8	0.0309	0.0297	0.033
	1250	39.9	40.5	43.9	0.0393	0.0383	0.045
	1500	48.3	49.6	53.0	0.0480	0.0469	0.055
500	300	5.2	5.6	6.5	0.0041	0.0035	0.0058
	600	10.6	11.6	12.8	0.0071	0.0090	0.011
	1000	17.8	18.9	21.0	0.0146	0.0147	0.017
	1250	22.1	22.8	22.8	0.0175	0.0183	0.0207
	1500	25.8	27.0	29.8	0.0216	0.0220	0.0246

Table 34

Evaluation of generalized correlations for isothermal effect of pressure on enthalpy of ethane. (Source of observed values: York & Weber,[29] Sage Webster & Lacey.[33])

T_r	P_r	Obs. −ΔH, Btu./Lb. Mol.		Calc. −ΔH, Btu./Lb. Mol.		
		Y. & W.[29]	S. W. & L.[33]	Fig. 48	H. & W.[12]	Y. & W.[30, 31]
1.00	0.25	289	301	329	329	308
	0.50	677	683	724	735	642
	1.00	.....	3040	2970	2970	2700
	2.00	.....	4180	4860	4750	4130
	3.00	.....	4300	4960	4910	4270
1.20	0.50	443	421	448	475	433
	1.00	938	932	950	1025	924
	2.00	2220	2225	2160	2265	2155
	3.00	3105	3160	2970	3190	3135
1.50	1.00	562	.....	540	615	588
	2.00	1107	.....	1101	1191	1138
	3.00	1602	.....	1620	1727	1623
	5.00	2321	.....	2290	2430	2340

Table 35

Evaluation of generalized correlations for isothermal effect of pressure on enthalpy of propane. (Source of observed values: York and Weber.[29])

T_r	P_r	−ΔH, Btu./Lb. Obs.[29]	Fig. 48	W. & S.[26]	H. & W.[12]
1.0	1.0	80.9	86.6	68	83.4
	3.0	126.0	138.0	133	138.2
1.10	1	35.0	35.2	36.2	37.9
	3	107.9	105.2	99.8	114.2
	5	116	114.2	107.0	123.4
1.2	1	26.1	26.6	27.2	28.8
	3	86.9	83.5	78.5	89.4
	5	101.5	96.2	89.1	104.7
1.3	1	21.6	21.3	22.6	23.3
	3	68.4	67.9	65.0	71.9
	5	88.3	85.0	78.5	90.9
1.4	1	18.4	18.0	18.1	19.9
	3	55.0	55.1	53.0	59.1
	5	76.3	74.5	69.5	78.2
1.5	1	16.6	15.4	16.6	17.3
	3	45.9	45.6	46.8	48.5
	5	66.1	64.9	60.5	68.2

Table 36

Evaluation of generalized correlations for isothermal effects of pressure on enthalpy and entropy of isobutane. (Source of observed values: Sage and Lacey.[22])

Temperature, °F.	Pressure Psia.	−ΔH, Btu/Lb. Obs.[22]	Fig. 48	H. & W.[12]	−ΔS', Btu./(Lb.) (°R) Obs.[22]	Fig. 49	H. & W.[12]
70	40	2.64	3.28	4.86	0.0034	0.0045	0.0071
100	40	2.08	2.82	3.72	0.0024	0.0035	0.0051
	60	4.24	5.21	6.75	0.0032	0.0067	0.0097
160	40	1.41	2.23	3.89	0.0012	0.0024	0.0024
	60	2.80	4.10	4.67	0.0027	0.0046	0.0059
	100	6.07	8.11	9.47	0.0063	0.0092	0.012
	150	11.23	13.9	16.9	0.0124	0.0161	0.0223
220	40	1.05	1.77	2.84	0.0006	0.0017	0.0021
	60	2.05	3.07	4.29	0.0015	0.0031	0.0038
	100	4.55	6.04	7.70	0.0036	0.0062	0.009
	150	8.45	10.01	12.1	0.0075	0.0106	0.0168
	200	13.07	14.81	17.4	0.0125	0.0156	0.0183
	300	24.01	27.40	38.5	0.0244	0.0306	0.0352

Table 37

Evaluation of generalized correlations for isothermal effects of pressure on enthalpy and entropy of *n*-Butane. (Source of observed values: Prengle, York and Greenhaus.[23])

Temperature, °F.	Pressure, Atm.	−ΔH, Btu./Lb. Obs.[15]	Fig. 48	H. & W.[12]	−ΔS', Btu./Lb. °R Obs.[15]	Fig. 49	H. & W.[12]
160	4	5.1	6.0	7.3	0.0046	0.0073	0.0103
	8	11.1	13.4	16.9	0.0099	0.0147	0.0207
200	6	6.7	7.91	9.0	0.0057	0.0829	0.107
	10	12.3	14.5	16.5	0.112	0.155	0.198
260	8	7.7	7.91	9.0	0.0068	0.0078	0.0092
	15	16.1	17.1	19.1	0.0145	0.0169	0.0199
	20	23.7	28.8	29.7	0.0227	0.0267	0.0311
300	15	13.4	13.5	13.9	0.0115	0.0122	0.0126
	30	33.4	34.6	36.2	0.0319	0.0345	0.0342
	50	106.2	113.4	109.5	0.1142	0.105	0.121
	100	114.5	121.5	119.0	0.1044	0.104	0.117
	200	120.3	122.8	123.0	0.093	0.098	0.110
400	10	6.5	6.5	7.1	0.0042	0.0052	0.0052
	50	42.4	43.5	46.1	0.0372	0.0381	0.0431
	100	89.8	85.8	92.5	0.0754	0.0741	0.0830
	200	101.1	96.4	103.0	0.0650	0.0758	0.0863
500	10	5.2	5.0	5.7	0.0032	0.0037	0.0043
	50	28.8	28.4	30.4	0.0222	0.0207	0.0276
	100	61.4	58.7	62.0	0.0494	0.0449	0.0491
	200	84.9	76.5	85.9	0.0540	0.0509	0.0655

are included in the enthalpy comparisons.

It is obviously impossible to include in these comparisons all of the data available or to report in these pages all of the results in detail. The values reported in the tables of this installment are representative points from the comparisons made, being about one-third in number. The points chosen in turn represent a similar fraction of the total available points.

The data were in various forms and usually had to be converted to comparable units. In the tables of thermodynamic properties the values of H and S from the tables were used to calculate $-\Delta H$ and $-\Delta S'$. In most cases these were taken as $H_P - H_1$ (H_1 = enthalpy at one atmosphere) as the difference between H° and H_1 is usually negligible, and as

$$[S^\circ - R \ln P - S]_{Press} - [S^\circ - R \ln P - S]_{1atm}$$

In the latter relationship for evaluating $-\Delta S'$, the datum entropy, S°, drops out.

Comparisons of Observed and Calculated Pressure Corrections

Tables 31 through 48 give the comparisons of observed and calculated $-\Delta H$ and $-\Delta S'$ data. In some cases more than one *observed* column of values is given. In all cases more than one calculation method is shown. Figures 48 and 49, representing the proposed new correlations, and the comparable Hougen and Watson[12] charts are used in calculating values of $-\Delta H$ and $-\Delta S'$ for the comparisons.

In addition, the charts of Watson and Smith[26] and of York and Weber[29, 31] were used for some of the systems but not all. In applying the York and Weber enthalpy pressure correction correlation, their proposed ϕ correction factor was employed. The companion entropy chart was applied without such a factor because none was included by the author.[31]

In many cases the authors of technical papers on this subject included comparisons with other data and/or calculation methods. These comparisons were of great assistance in preparing those given in Tables 31 through 48. Also the writer is indebted to M. Benedict et al. at Hydrocarbon Research Inc., for assistance in some of the calculations for the hydrocarbon mixtures. In addition, the assistance of students in an evening class in thermodynamics at New York University helped prepare these comparisons.

Tables 31 through 48 summarize the comparisons actually made. About twice as many points were calculated. The points listed in these tables are typical. In comparing the values of $-\Delta H$ and $-\Delta S'$ given in these tables, it should be borne in mind that the numerical values listed are only parts of the enthalpy or entropy and that in many cases these represent small parts. For example, the effect of temperature on the enthalpy for a given process is often more significant than the effect of pressure. In the case of the entropy, the values of $-\Delta S'$ given represent part of the pressure correction. In other words, $-\Delta S'$ is a "residual" entropy correction.

Comparisons of small numbers that

are differences and residuals, such as $-\Delta H$ and $-\Delta S'$, might be expected to show large deviations, which they do as can be seen in these tables. It is interesting to note, however, that the deviations are frequently higher, on a percentage basis, at the lower pressures where the pressure corrections are lowest. Where the value of $-\Delta H$ is 2 Btu./lb. an error of 1 Btu./lb. is 50 percent but where at higher pressures an error of 1 Btu./lb. is a lower percentage but not less important.

Other points of interest in this connection are 1) The data of Sage and Lacey et al. on ethane and n-butane are below the values of York et al. for these same compounds and of Barkelew et al. for ethane. From this comparison and for reasons brought out by the authors[1, 18, 20] it would appear that the values of Sage and Lacey are low and that their values are probably low for isobutane as well; 2) In applying the Hougen and Watson[12] enthalpy correlation, the Φ correction factor was not used because it was limited to temperatures above $T_r = 1.0$ and because there was no comparable correction factor for entropy. The use of this factor would have improved the calculated values slightly for the lower boiling hydrocarbons. It would not change n-pentane, the reference substance in Hougen and Watson's correlation, and it would have made the agreement for benzene worse; 3) The York and Weber correlations are clearly better for the points on pure components compared, i.e. ethane, propane and n-pentane above $T_r = 1.0$; 4) The benzene values of $-\Delta H$ and $-\Delta S'$ by Organick and Studhalter are not of the same high degree of accuracy as the similar compilations for methane, ethelyne, ethane and n-butane, because of the limitations in the P-V-T data the authors had to work with.

Accuracy and Limitations of Generalized Correlations for Effects of Pressure

The deviations of the calculated values of the enthalpy corrections from the observed data have been computed for the hydrocarbons indicated in Table 49, where the deviations for both Figure 48 and Hougen and Watson's chart are listed. It will be noted that some of the data given in previous tables were not used (i.e. Tables 34, 36, 38, 43) and that the deviations were computed for more points than listed in the tables given here.

Three average deviations are given, *plus*, *minus* and *over-all*. The over-all deviation is the average of all deviations disregarding the signs. From this

Table 38
Evaluation of generalized correlations for isothermal pressure corrections to enthalpy and entropy of n-Butane. (Source of observed values: Sage, Webster & Lacey.[24])

Temperature, °F.	Pressure Psia.	$-\Delta H$, Btu./Lb.			$-\Delta S'$, Btu./Lb. °R		
		Obs.[24]	Fig. 48	H. & W.[12]	Obs.[24]	Fig. 49	H. & W.[12]
70	30	2.05	2.1	4.0	0.00265	0.00284	0.00523
100	30	1.52	1.9	2.8	0.00175	0.00186	0.00396
	50	4.03	4.8	7.1	0.0048	0.00606	0.00923
130	30	1.31	1.7	2.1	0.00135	0.00189	0.00266
	50	3.31	4.2	5.4	0.0035	0.00465	0.00682
	80	6.76	8.0	10.4	0.0077	0.0095	0.01388
160	50	2.80	3.7	4.4	0.0027	0.00472	0.00554
	80	5.57	7.0	8.4	0.0061	0.00848	0.01066
	100	7.56	9.5	11.2	0.0087	0.01148	0.01496
190	50	2.39	3.3	3.6	0.0021	0.00341	0.00421
	80	4.74	6.2	7.1	0.0047	0.00678	0.00832
	100	6.40	8.3	9.4	0.0067	0.00887	0.0115
	150	10.97	14.0	18.0	0.0117	0.0157	0.0207
250	50	1.73	2.5	3.8	0.0013	0.00238	0.00396
	80	3.43	4.7	6.2	0.0026	0.00455	0.00560
	100	4.68	6.1	7.9	0.0038	0.00604	0.0081
	150	8.20	10.4	12.4	0.0072	0.01025	0.0131
	200	12.41	15.1	19.5	0.0112	0.0163	0.0189
	250	17.36	21.0	23.8	0.0168	0.0225	0.0267
	300	23.26	28.0	31.7	0.0229	0.0287	0.0345

Table 39
Evaluation of generalized correlations for isothermal effect of pressure on enthalpy of n-Pentane. (Source of observed values: Kenz and Brown[16]; and Gilliland and Parekh.[17])

T_r	P_r	Obs. $-\Delta H$, Btu./Lb.		Correlation $-\Delta H$, Btu./Lb.		
		K. & B.[16]	G. & P.[17]	Fig. 48	Y. & W.[20, 21]	H. & W.[12]
1.00	0.5	14.7	....	16.2	15.5	16.0
	0.75	25.8	....	27.6	27.0	28.8
	1.00	64.6	57.6	67.0	61.5	70.5
	1.50	92.9	103.0	103.0	95.8	100.0
	2.00	96.4	....	106.0	99.0	103.4
	3.00	100.5	111.0	108.3	102.9	107.0
1.10	0.50	9.6	....	11.9	10.9	12.3
	1.00	25.4	27.8	27.0	25.8	29.4
	1.50	44.3	....	51.4	47.6	54.6
	2.00	61.6	74.1	71.5	67.6	78.1
	4.00	82.0	97.0	86.8	82.2	93.5
	6.00	84.0	100.0	89.3	85.8	96.4
1.20	1.0	18.3	20.8	20.7	17.7	22.3
	2.0	40.3	....	47.0	40.2	49.4
	3.0	56.4	68.9	64.6	57.9	69.9
	6.0	69.0	86.3	75.5	68.9	84.6
1.4	1.5	19.3	20.0	21.3	17.1	22.9
	3.0	35.5	42.7	42.9	34.1	45.8
	6.0	51.4	61.5	58.7	49.5	64.0

Table 40
Evaluation of generalized correlations for isothermal effect of pressure on enthalpy of n-Heptane. (Source of observed values: Gilliland and Parekh.[17])

T_r	P_r	$-\Delta H$, Btu./Lb.			
		Obs.[17]	Fig. 48	Y. & W.[20, 21]	H. & W.[12]
1.0	0.6	19.8	19.0	20.4	19.8
	0.8	27.3	27.6	32.1	25.4
	1.0	59.6	64.4	66.0	67.8
	2.0	105.9	101.6	103.5	99.4
	4.0	112.6	104.5	108.9	103.9
	6.0	112.0	105.0	111.5	105.0
1.1	0.6	12.5	13.9	12.4	14.7
	2.0	67.1	68.9	76.8	73.4
	3.0	79.0	79.1	88.6	85.9
	6.0	88.6	85.9	96.6	92.6
1.2	0.5	7.0	9.4	9.7	9.9
	1.5	27.2	32.2	35.2	34.4
	3.0	57.4	62.1	70.2	66.6
	6.0	68.0	72.5	82.0	81.3

Table 41
Evaluation of generalized correlations for isothermal effect of pressure on enthalpy of Isooctane. (Source of observed values: Gilliland & Parekh.[17])

T_r	P_r	$-\Delta H$, Btu./Lb.			
		Obs.[17]	Fig. 48	Y. & W.[20, 21]	H. & W.[12]
1.047	0.72	20.6	15.9	17.2	12.0
	0.89	29.6	21.4	25.3	22.3
	2.91	81.0	69.5	74.0	71.2
1.15	0.81	15.8	13.5	14.9	14.6
	1.78	48.4	36.9	42.9	40.3
	2.91	61.7	51.7	59.2	56.6
	6.8	66.8	60.1	....	67.0

Table 42

Evaluation of generalized correlations for isothermal effect of pressure on enthalpy of benzene. (Sources of observed values: Gilliland & Lukes[9]; Organick & Studhalter.[17])

T_r	P_r	Obs. $-\Delta H$, Btu./Lb.		Correlation $-\Delta H$, Btu./Lb.		
		G. & L.[9]	O. & S.[17]	Fig. 48	Y. & W.[27, 28]	H. & W.[12]
1.0	0.6	24.3	23.2	21.2	.....	22.7
	0.8	35.6	35.5	33.2	.....	35.4
	1.0	77.1	78.9	73.5	81.3	78.0
	2.0	117.7	114.9	116.2	122.0	114.2
	3.0	120.6	117.0	119.0	126.5	118.2
	4.0	119.2	118.7	120.1	129.7	119.5
1.10	0.6	15.0	14.8	15.5	.....	16.9
	1.0	.....	28.6	29.9	31.0	32.5
	1.3	44.4	42.4	35.2	.....	49.4
	2.0	80.0	76.0	78.5	80.8	84.5
	3.0	92.0	91.0	90.4	93.6	98.9
	4.0	94.7	95.0	95.5	98.0	102.8
1.2	1	.....	19.1	22.9	20.9	24.7
	2	.....	44.4	52.0	47.7	54.6
	4	.....	73.0	79.3	75.8	85.5
1.3	1	.....	13.5	18.2	15.6	24.7
	2	.....	29.5	40.3	33.4	41.6
	4	.....	53.6	65.6	58.5	72.8

Table 43

Evaluation of generalized correlations for isothermal effect of pressure on entropy of benzene. (Source of observed values: Organick & Studhalter.[17])

T °F.	P psia.	$-\Delta S'$ Btu./Lb. °R			
		Obs.[17]	Fig. 49	York[31]	H. & W.[12]
300	81.95	0.0086	0.0074	.....	0.0113
400	221	0.0168	0.0160	.....	0.0199
553.1	715.7	0.0582	0.0577	0.0576	0.0641
	1000	0.0921	0.0789	0.0780	0.0899
	2000	0.0871	0.0772	0.0765	0.0871
	3000	0.0830	0.0749	0.0737	0.0846
800	400	0.0063	0.0060	0.00615	0.00692
	1000	0.0161	0.0165	0.0173	0.0192
	2000	0.0398	0.0359	0.0365	0.0410
	3000	0.0494	0.0423	0.0422	0.0488
1200	400	0.0023	0.0026	0.0026	0.0032
	1000	0.0061	0.0067	0.0071	0.0076
	2000	0.0122	0.0135	0.0135	0.0137
	3000	0.0177	0.0186	0.0188	0.0205
1600	400	0.0012	0.0016	0.0014	0.0022
	1000	0.0030	0.0041	0.0038	0.0050
	2000	0.0057	0.0077	0.0077	0.0087
	3000	0.0083	0.0105	0.0113	0.0115

Table 44

Evaluation of generalized correlations for isothermal effect of pressure on enthalpy of methane-ethane mixtures. (Source of observed values: Calculations on data of Budenholzer, Sage & Lacey.[2])

Temp. °F.	Pressure, Psia.	$-\Delta H$, Btu./Lb. for 25 Mol % CH_4 System T_{pc} = 499° R; P_{pc} = 700 Psia.				$-\Delta H$, Btu./Lb. for 50 Mol % CH_4 System T_{pc} = 447° R; P_{pc} = 691 Psia.				$-\Delta H$, Btu./Lb. for 75 Mol % CH_4 System T_{pc} = 396° R; P_{pc} = 682 Psia.			
		Obs.[5]	Fig. 48	H. & W.[12]	Y. & W.[29, 31]	Obs.[5]	Fig. 48	H. & W.[12]	Y. & W.[29, 31]	Obs.[5]	Fig. 48	H. & W.[12]	Y. & W.[29, 31]
70	250	12.9	13.9	14.8	13.4	10.7	11.8	12.8	10.2	8.7	9.2	10.4	8.2
	500	30.6	31.4	33.8	30.4	23.8	24.0	26.6	23.2	18.6	18.8	20.7	17.2
	750	54.8	57.5	62.0	73.6	38.9	37.8	42.8	37.4	29.2	27.7	31.5	26.4
	1000	.....	.....	.....	.....	53.4	54.2	62.2	54.4	40.4	37.0	53.9	36.2
	1500	.....	.....	.....	.....	84.1	98.7	95.4	84.6	63.1	60.7	65.0	56.1
160	250	8.9	9.8	10.9	9.2	7.4	8.2	9.0	7.6	6.2	6.7	6.8	6.7
	500	19.3	20.0	22.0	19.5	15.8	16.7	18.3	15.6	12.9	13.7	15.4	13.5
	750	31.0	30.7	34.8	30.4	24.7	25.3	27.2	24.0	19.9	20.6	23.3	20.0
	1000	44.0	43.2	47.9	42.5	34.1	34.2	36.5	32.4	27.0	27.4	30.8	26.6
	1500	71.3	69.4	75.1	68.1	53.0	51.9	54.4	49.5	40.7	41.2	44.6	39.8
220	250	7.3	8.3	9.2	8.0	6.2	6.6	7.6	6.8	5.2	5.6	6.5	.....
	500	15.5	16.6	18.6	16.1	13.1	14.4	15.6	13.7	10.7	11.3	14.8	.....
	750	24.4	25.2	28.2	25.0	20.1	19.8	23.4	21.0	16.4	17.2	19.1	.....
	1000	33.8	33.8	37.9	33.9	27.3	28.2	30.5	27.7	22.0	22.3	24.6	.....
	1500	52.9	51.4	56.4	51.7	41.6	42.8	44.7	40.4	32.9	32.3	45.0	.....

Table 45

Evaluation of generalized correlations for isothermal effect of pressure on enthalpy of methane-propane mixtures. (Source of observed values: Calculations based on data of Budenholzer, Botkin, Sage & Lacey.[1])

Temp. °F.	Pressure, Psia.	$-\Delta H$ Btu. Lb. for 47.25 Mol. % CH_4 System T_{pc} = 515° R; P_{pc} = 644 Psia.				$-\Delta H$, Btu./Lb. for 72.8 Mol. % CH_4 System T_{pc} = 432 °R; P_{pc} = 666 Psia.				$-\Delta H$, Btu./Lb. for 89.45 Mol. % CH_4 System T_{pc} = 378 °R; P_{pc} = 667 Psia.			
		Obs.[7]	Fig. 48	H. & W.[12]	Y. & W.[29, 31]	Obs.[7]	Fig. 48	H. & W.[12]	Y. & W.[29, 31]	Obs.[7]	Fig. 48	H. & W.[12]	Y. & W.[29, 31]
70	200	12.6	12.1	11.9	11.1	9.0	8.4	9.2	7.5	7.0	6.5	7.7	5.4
	400	.....	.....	.....	.....	18.9	16.9	18.3	16.8	14.6	13.5	15.6	12.0
	600	.....	.....	.....	.....	29.8	25.8	28.4	25.1	22.7	20.8	23.4	19.7
	1000	.....	.....	.....	.....	.....	.....	.....	.....	40.5	35.7	38.9	33.5
	1500	.....	.....	.....	.....	.....	.....	.....	.....	66.0	53.4	58.5	51.1
190	200	7.6	7.2	7.0	7.4	5.7	5.6	6.2	5.8	4.7	4.6	5.2	.....
	400	16.4	14.8	16.6	15.6	11.8	11.4	12.5	11.3	9.5	9.2	10.3	.....
	600	26.1	22.9	26.4	24.1	18.1	17.0	18.6	16.9	14.5	13.8	15.4	.....
	1000	47.9	40.6	46.0	42.6	30.6	28.4	31.1	27.6	24.5	22.6	24.9	.....
	1500	71.5	64.6	70.4	67.1	45.3	43.3	45.0	40.6	36.5	32.3	35.1	.....
310	200	5.1	5.1	5.9	5.6	4.0	4.0	4.5	.....	3.3	3.4	3.8	.....
	400	10.4	10.3	11.9	11.3	8.1	8.0	9.0	.....	6.7	6.8	7.6	.....
	600	16.1	16.1	17.6	16.6	12.3	12.0	13.4	.....	10.2	9.9	11.2	.....
	1000	28.2	26.8	29.3	27.6	20.8	19.7	21.2	.....	17.1	16.2	17.7	.....
	1500	43.4	41.8	42.6	40.3	30.8	29.2	30.0	.....	24.9	22.5	24.9	.....

information it may be concluded that Figure 48 is to be preferred over the comparable Hougen and Watson chart, when the latter is applied without the ϕ factor, and is probably better even with the ϕ factor because the latter adds an extra calculation step but will not increase the accuracy enough to justify the additional trouble.

Figure 48 is a convenient generalized correlation that will give results of sufficient accuracy for most engineering design work. It should not be used in preparing Mollier diagrams when a high degree of precision is desired.

A similar evaluation for Figure 49 is not presented because of the limited amount of observed entropy data available for comparisons. An examination of the data that are available along with calculated values indicate that the deviations in $-\Delta S'$ are rather large for methane but low for ethylene and ethane and in between for n-butane and benzene. The real test of Figure 49 is in the calculation of the temperature change for isentropic paths, such as in the example presented earlier in this installment. Space does not permit making these calculations and comparisons.

REFERENCES

[1] Barkelew, C. H., Valentine, J. L. and Hurd, C. O., "Thermodynamic Properties of Ethane," Chem. Eng. Prog. 43, 25 (1947).

[2] Brown, G. G., Lewis, W. K., and Weber,

Table 46

Evaluation of generalized correlations for isothermal effect of pressure on enthalpy of methane-n-butane mixtures. (Source of observed values: Calculations based on data of Budenholzer, Sage & Lacey.[6])

Temp. °F.	Pressure, Psia.	—△H, Btu./Lb. for 78.37 Mol. % CH_4 System T_{pc} = 436° R; P_{pc} = 646 Psia.				—△H, Btu./Lb. for 89.42 Mol. % CH_4 System T_{pc} = 387° R; P_{pc} = 660 Psia.				—△H, Btu./Lb. for 97.82 Mol. % CH_4 System T_{pc} = 357° R; P_{pc} = 669 Psia.			
		Obs.[6]	Fig. 48	H. & W.[12]	Y. & W.[29, 31]	Obs.[6]	Fig. 48	H. & W.[12]	Y. & W.[29, 31]	Obs.[6]	Fig. 48	H. & W.[12]	Y. & W.[29, 31]
70	250	.....	.....	.....	.....	8.2	9.1	8.3	7.8	7.1	8.1	9.0	7.7
	500	.....	.....	.....	.....	.....	.....	.....	.....	14.7	16.4	18.2	15.7
190	250	6.8	7.0	7.7	6.8	5.5	5.8	6.6	.....	4.8	5.3	5.1	.....
	500	14.2	15.2	15.5	13.8	11.4	11.9	13.1	.....	9.8	10.6	11.9	.....
	1000	.....	.....	.....	.....	23.5	23.4	22.4	.....	20.0	20.4	22.8	.....
	1500	.....	.....	.....	.....	.....	.....	.....	.....	29.5	29.7	33.1	.....
310	250	4.7	5.2	5.6	.....	3.9	4.4	4.8	.....	3.2	4.2	4.5	.....
	500	9.7	10.8	11.0	.....	7.9	8.7	9.4	.....	6.5	7.9	8.89	.....
	1000	19.7	21.0	20.9	.....	16.0	16.7	17.8	.....	13.0	15.2	16.5	.....
	1500	29.3	30.4	29.6	.....	23.6	24.1	23.8	.....	19.1	21.8	23.4	.....

Table 47

Evaluation of generalized correlations for isothermal effect of pressure on enthalpy of methane-n-pentane mixtures. (Source of observed values: Sage, Reamer, Olds and Lacey.[20])

Temp °F.	Pressure, Psia.	—△H, Btu./Lb. for 29.33 Mol. % CH_4 System T_{pc} = 698° R; P_{pc} = 539 Psia.				—△H, Btu./Lb. for 73.85 Mol. % CH_4 System T_{pc} = 476° R; P_{pc} = 624 Psia.				—△H, Btu./Lb. for 94.01 Mol. % CH_4 System T_{pc} = 375° R; P_{pc} = 663 Psia.		
		Obs.[10]	Fig. 48	H. & W.[12]	Y. & W.[29, 31]	Obs.[10]	Fig. 48	H. & W.[12]	Y. & W.[29, 31]	Obs.[10]	Fig. 48	H. & W.[12]
280	200	.....	.....	.....	.....	5.9	5.8	5.3	5.2	3.6	3.4	4.0
	600	.....	.....	.....	.....	18.4	15.4	16.0	14.3	10.8	10.2	11.5
	1000	.....	.....	.....	.....	31.9	26.2	26.0	23.6	17.9	16.4	19.3
	1600	.....	.....	.....	.....	51.1	40.6	39.6	36.2	28.0	24.6	27.0
	2400	.....	.....	.....	.....	68.8	57.1	56.0	50.1	39.8	34.2	36.6
	3600	.....	.....	.....	.....	82.5	71.2	70.0	64.2	52.8	46.4	47.2
400	200	8.7	8.2	7.6	6.9	4.2	3.9	4.0	.....	2.3	2.3	3.2
	600	29.9	28.2	28.0	23.2	12.7	11.6	11.7	.....	6.8	8.2	9.1
	1000	55.2	48.1	45.1	43.4	21.0	18.8	18.7	.....	11.3	13.2	14.8
	1600	79.3	74.3	68.9	67.4	33.0	28.7	28.0	.....	18.0	19.9	20.3
	2400	90.0	86.0	80.2	79.3	46.2	39.6	38.4	.....	26.2	27.8	27.0
	3600	94.6	97.2	87.7	.....	59.0	51.8	50.5	.....	35.6	37.1	33.9

H. C., "Physical Factors Governing Cracking Operations," Ind. Eng. Chem. **26**, 325 (1934).

[2] Brown, G. G., "A Series of Enthalpy-Entropy Charts for Natural Gases," American Inst. of Mining & Metallurgical Engineers Technical Publication No. 1747 (1944).

[6] Budenholzer, R. A., Sage, B. H. and Lacey, W. N., "Joule-Thomson Coefficients of Methane," Ind. Eng. Chem. **31**, 369 (1939).

[6] Budenholzer, R. A., Sage, B. H. and Lacey, W. N., "Joule-Thomson Coefficient of Gaseous Mixtures of Methane and Ethane," Ind. Eng. Chem. **31**, 1288 (1939).

[6] Budenholzer, R. A., Sage, B. H. and Lacey, W. N., "Joule-Thomson Coefficients for Gaseous Mixtures of Methane and n-Butane," Ind. Eng. Chem. **32**, 384 (1940).

[7] Budenholzer, R. A., Botkin, D. F., Sage, B. H. and Lacey, W. N., "Joule-Thomson Coefficients in Methane-Propane Systems," Ind. Eng. Chem. **34**, 878 (1942).

[8] Dodge, B. F., "Chemical Engineering Thermodynamics," McGraw-Hill, New York (1944).

[9] Gilliland, E. R. and Lukes, R. V., "Effect of Pressure on the Enthalpy of Benzene," Ind. Eng. Chem., **32**, 957 (1940).

[10] Gilliland, E. R., Lukes, R. V. and Scheeline, H. W., "Physical Properties of Hydrocarbons and Their Mixtures," Am. Inst. Mining & Met'l. Eng.: Tech. Pub. **1060**, 14 (1939).

[11] Gilliland, E. R. and Parekh, M. D., "Effect of Pressure on Enthalpy of Pentane, Heptane and Isooctane," Ind. Eng. Chem., **34**, 360 (1942).

[12] Hougen, O. A. and Watson, K. M., "Chemical Process Principles—Part Two—Thermodynamics," "Chemical Process Charts," John Wiley & Sons, New York (1947).

[13] Kennedy, E. R., Sage, B. H. and Lacey, W. N., "Joule-Thomson Coefficients of n-Butane and n-Pentane," Ind. Eng. Chem., **28**, 718 (1936).

[14] Konz, P. R. and Brown, G. G., "Thermal Properties of Pentane," Ind. Eng. Chem. **33**, 617 (1941).

[15] Lindsay, J. D. and Brown, G. G., "Thermal Properties of Benzene," Ind. Eng. Chem., **27**, 817 (1935).

[16] Matthew, C. S. and Hurd, C. O., "Thermodynamic Properties of Methane," Trans. Amer. Inst. of Chem. Eng., **42**, 55 (1946).

[17] Organick, E. I. and Studhalter, W. R., "Thermodynamic Properties of Benzene," Chem. Eng. Progress, **44**, 847 (1948).

[18] Prengle, H. W., York, R. and Greenhaus, L. R., "Thermodynamic Properties of n-Butane," Chem. Eng. Progress, **44**, 863 (1948).

[19] Sage, B. H., Reamer, H. H., Olds, R. H. and Lacey, W. N., "Volumetric and Phase

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Table 48

Evaluation of generalized correlation for isothermal effect of pressure on enthalpy of two natural gases. (Source of observed values: Sage, Botkin and Lacey.[20])

T. °F	Pressure, Psia.	—△H, Btu./Lb., for Natural Gas A				—△H, Btu./Lb., for Natural Gas B			
		Obs.[20]	Fig. 48	H. & W.[12]	Y. & W.[29, 31]	Obs.[20]	Fig. 48	H. & W.[12]	Y. & W.[29, 31]
70	200	6.8	7.1	7.8	6.2	6.6	6.2	7.4	6.1
	400	14.0	14.2	16.3	13.3	13.4	12.8	15.0	12.6
	600	21.5	21.5	24.3	20.7	20.5	19.4	22.5	18.4
130	200	5.7	5.7	6.4	6.1	5.5	5.4	6.2	5.3
	400	11.8	11.6	13.0	11.4	11.2	11.1	12.3	10.9
	600	18.2	17.6	19.7	17.3	17.0	16.7	19.3	16.9
190	200	4.8	4.8	5.4	.....	4.5	4.3	5.0	.....
	400	10.0	9.6	10.9	.....	9.2	8.6	9.8	.....
	600	15.2	14.6	16.3	.....	13.8	12.8	14.8	.....
250	200	4.0	4.1	4.6	.....	3.8	3.8	4.3	.....
	400	8.3	8.4	9.1	.....	7.6	7.6	8.6	.....
	600	12.6	12.4	13.4	.....	11.5	11.4	12.7	.....
310	200	3.3	3.6	4.1	.....	3.1	3.3	3.8	.....
	400	6.8	7.1	8.0	.....	6.2	6.2	7.4	.....
	600	10.3	10.6	11.4	.....	9.4	9.4	10.9	.....

Table 49

Average deviations of calculated from observed isothermal pressure corrections to enthalpy of hydrocarbon vapors.

Hydrocarbons	OBSERVED DATA: Reference	No. of Points	Table No.	AVERAGE DEVIATIONS, PERCENT: Fig. 48 Plus	Fig. 48 Minus	Fig. 48 Overall	H. & W.[12] Plus	H. & W.[12] Minus	H. & W.[12] Over-all
Methane	16	32	31	3.2	7.9	4.7	14.4	5.8	13.2
Ethylene	30	33	32	9.0	3.5	6.5	13.3	.....	13.3
Ethane	1	32	33	6.2	1.8	5.2	14.2	4.2	13.9
Propane	29	26	35	4.7	2.0	2.7	5.8	.....	5.8
n-Butane	18	44	37	10.4	5.2	9.0	22.8	1.4	21.6
n-Pentane	14	22	39	13.3	.....	13.3	20.4	.....	20.4
n-Heptane	11	14	40	6.3	4.4	5.5	9.4	6.8	8.7
iso-Octane	11	9	41	3.3	17.4	10.4	0.3	16.3	8.3
Benzene	17	20	42	13.7	3.8	12.2	23.4	2.9	18.3
MIXTURES:									
Methane-Ethane	5	45	44	5.0	3.1	4.5	14.5	.....	14.5
Methane-Propane	7	39	45	2.8	7.0	6.2	7.0	4.2	6.2
Methane-Butane	6	24	46	5.7	0.4	5.5	21.3	4.7	20.6
Methane-Pentane	19	30	47	8.7	11.3	10.7	17.5	12.5	13.9
Natural Gas A	20	15	48	2.6	2.9	2.7	11.7	.....	11.7
Natural Gas B	20	15	48	1.3	4.0	3.1	12.3	.....	12.3

← Rear of General Petroleum Corporation's vacuum tank truck just after the operator has connected suction hose to pump out skimming pit. Dumping valve is in line from rear center of the tank. Compressor is at front end of the skid-mounted unit.

Portable Vacuum Tank Proves Useful

C. C. PRYOR, Associate Editor

THERE are many times in a refinery when sump pits and tanks, spills, sewers, and skimming tanks require pumping out for one reason or another, such as plugged drain connections. Removal of odd batches of liquid waste is generally a disagreeable and unpleasant task, principally because of the means—bucket brigades, ditching, portable pumps, etc. —employed for the removal job. These methods, makeshift at best, in addition are costly and time-consuming. The use of portable pumps for this service is not generally satisfactory because the liquid being pumped may contain solids that damage the pump, and because such pumps often require fairly extensive makeshift piping for suction and discharge lines.

At the Torrance, Calif., refinery of General Petroleum Corporation, a portable vacuum tank and pump is being used very successfully for such services. As pictured, the tank, evacuation compressor, gasoline engine, and connecting piping, are skid-mounted as a single unit. When the tank is not in use, the unit is skidded from its carrier trailer and stored on a ramp, thus freeing the truck and trailer for other service. This unit, compact and simple in operation, is quickly and easily available in an emergency. It has been an aid to trouble-free operations and a clean plant.

The compressor at one end of the skid frame is driven by a small gasoline engine and pulls a vacuum on the storage drum. A heavy-duty hose connected to the rear of the drum is used as a liquid suction line. When the drum has been filled, the compressor is stopped, the hose valve at the rear of the drum closed, the hose disconnected and the load hauled to the point of final disposal.

When it is desirable for unloading purposes, the compressor suction and discharge can be reversed with valves, and liquids forced from the drum under positive pressure.

The vacuum line from the compressor to the tank is equipped with a filter to prevent solid materials from entering.

Small gasoline engine used to drive compressor is between the tank and compressor. Manifolding of piping permits compressor suction to be reversed to force material from the tank.

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Behavior of Methane -n-Pentane System," Ind. Eng. Chem., **34**, 1108 (1942).

[26] Sage, B. H., Botkin, D. F. and Lacey, W. N., "Joule-Thomson Coefficients for Two Natural Gases," Amer. Inst. of Mining & Met'l Eng. Tech. Pub. No. 1394, Petroleum Technology (September, 1942).

[27] Sage, B. H., Kennedy, E. R. and Lacey, W. N., "Joule-Thomson Coefficients of Propane," Ind. Eng. Chem., **28**, 601 (1936).

[28] Sage, B. H., and Lacey, W. N., "Thermodynamic Properties of Isobutane," Ind. Eng. Chem., **30**, 673 (1938).

[29] Sage, B. H., Webster, D. C. and Lacey, W. N., "Thermodynamic Properties of Ethane," Ind. Eng. Chem., **29**, 658 (1937); **32**, 388 (1940).

[30] Sage, B. H., Webster, D. C. and Lacey, W. N., "Thermodynamic Properties of n-Butane," Ind. Eng. Chem., **29**, 1188 (1937).

[31] Watson, K. M. and Nelson, E. F., "Improved Methods for Approximating Critical and Thermal Properties of Petroleum Fractions," Ind. Eng. Chem., **25**, 880 (1933).

[32] Watson, K. M. and Smith, R. L., "Generalized High Pressure Properties of Gases," National Petroleum News (Tech. Sect.), July 1, 1936.

[37] Weber, H. C., "Thermodynamics for Chemical Engineers," John Wiley & Sons, New York (1939).

[39] York, R., "Thermodynamic Properties from P-V-T Data," Ind. Eng. Chem., **32**, 54 (1940).

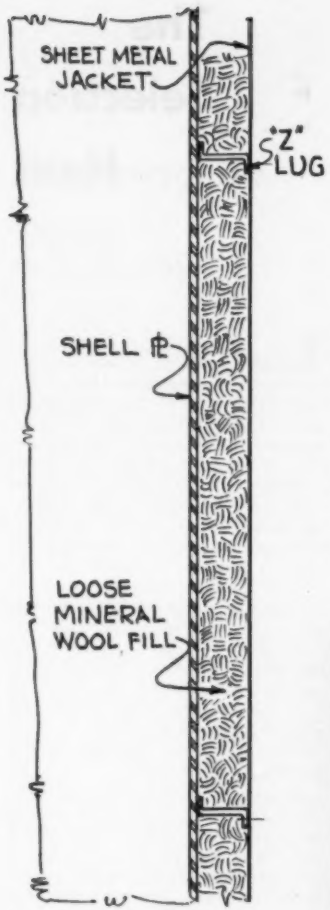
[40] York, R. and Weber, H. C., "Isothermal Changes in Enthalpy for Some Gases," Ind. Eng. Chem., **32**, 388 (1940).

[50] York, R. and White, E. F., "Thermodynamic Properties of Ethylene," Trans. Amer. Inst. of Chem. Engrs., **40**, 227 (1944).

[51] York, R., Jr., "Private Communications," (1941).

End Part XVI. Part XVII. will appear in the March issue.

Loose Mineral Wool Used for TANK INSULATION



Section through tank shell.

TO MINIMIZE heating requirements and keep viscous oils in a fluid state, two tanks at Montreal, Canada, shown in the accompanying photograph, were insulated with a 3-inch thickness of loose mineral wool.

Aluminum sheets were fastened to the tank surfaces by means of "Z" lugs. Loose mineral wool was installed between the sheets and the tank at each rise of sheets.

Mineral wool used in this application is considered satisfactory because it remains in place without settling when installed at the proper density. It has this property because the fibers of the loose irregular mass knit themselves together and exert internal pressure on every part of the mass sufficient to support every part directly adjacent and above it. The weight of every part is not enough to exert a downward force sufficient to counteract this internal mass pressure which is exerted in all directions.

The aluminum sheets not only serve the purpose of supporting the insulation, but also act as a vapor seal and weather protector, replacing weatherproof coatings of asphalt or similar material which would otherwise be required.

Photo is used by courtesy of the Industrial Mineral Wool Institute, 441 Lexington Avenue, New York 17.

Construction view showing the installation of aluminum jacketing over tank shells in a process plant. Regularly spaced "Z" clips serve to position the metal jackets concentrically, and to provide adequate support. The low weight of the large aluminum jacket sheets used is a major convenience during construction. Light weight access scaffolding can be employed to good advantage. Aluminum jacketing on lefthand tank is about half way up, whereas that on the righthand tank is complete except for half of the top ring.

The Selection Heat

CHARLES F.
Sanderson-Glendening,

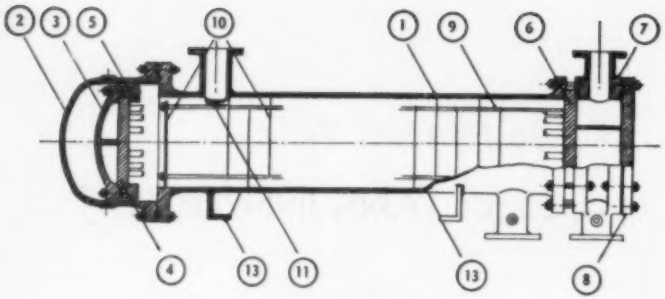


Figure A. Single-Pass Shell

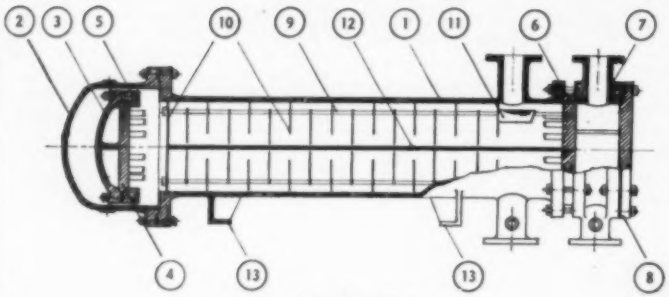


Figure B. Two-Pass Shell

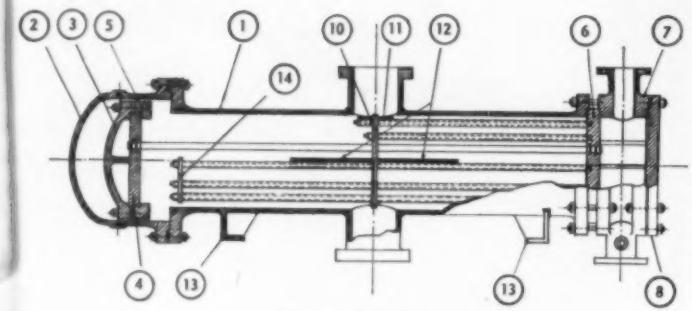


Figure C. Condenser

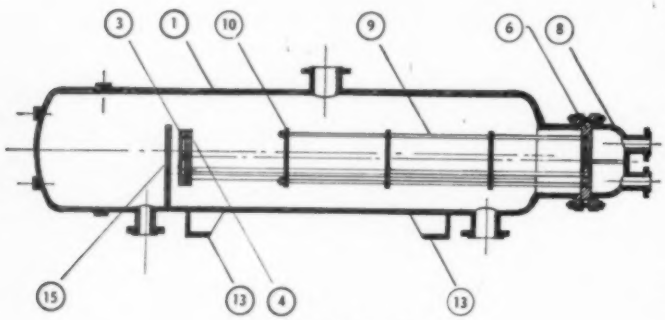


Figure D. Kettle-Type Boiler

THERMAL design is based on the well-known relationship which states that the amount of heat transferred per unit time is the product of the active area, the effective temperature difference and the over-all heat transfer coefficient. Of these factors, the one most easily determined is the area active in the transfer of heat. In double pipe and atmospheric sections this area is usually computed on the straight length of pipe; the small additional area in the return bends being left as a factor of safety. This also holds true for U-tube bundles where the ratio of diameter to length is small. However, in some of the larger reboilers it has been found safe to consider the area in the bends as being active, as this can constitute a fair percentage of the total.

In the usual tubular exchanger, where the area is made up of straight tubes rolled into a tube sheet at each end, the area is usually calculated on the entire tube length, including that in the tube sheet. This is admittedly in error, but is partly compensated for by heat transfer through the tube sheets and the fact that the total tube sheet thickness usually adds up to only a small fraction of tube length.

The next factor for consideration is the effective temperature difference. The term "effective" should be emphasized here, since it quite often differs appreciably from the apparent difference. The simplest case is that for pure concurrent or countercurrent

NOMENCLATURE

Standardized nomenclature is suggested at the left in sketches which are merely illustrative for purposes of indicating names of parts as follows:

1, Shell; 2, shell cover; 3, floating head cover; 4, floating tube sheet; 5, clamp ring or hook bolts; 6, stationary tube sheets; 7, channel; 8, channel cover (in Figure D, stationary end cover); 9, tie rods and spacers; 10, transverse baffles or tube support plates; 11, inpingement baffle; 12, longitudinal baffle; 13, saddles; 14, floating end support plate; 15, weir.

(From Tubular Exchanger Manufacturers Association.)

# of Exchangers

SANDERSON
Houston, Texas

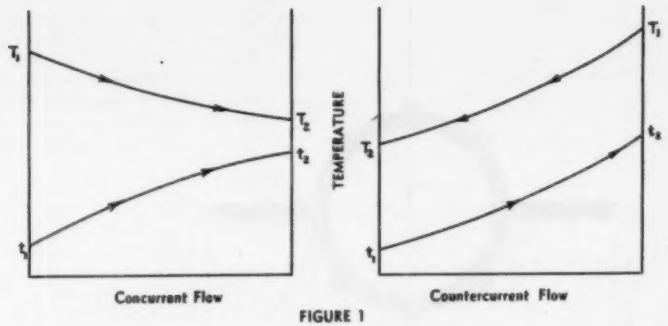


FIGURE 1

***THIS ARTICLE** is meant primarily for the engineer who, in the course of his duties, must decide upon the suitability of an existing piece of heat exchange equipment for a particular service. Or, having nothing usable in the salvage yard, must prepare specifications which will completely describe a unit to be purchased. It will be necessary for him to make decisions concerning both thermal and mechanical design and, since these factors are mutually dependent, both will be treated here.*

flows. (Figure 1.) Assuming that the specific heats of the two streams and the heat transfer coefficients are constant throughout, the effective temperature difference will be the log mean of the two terminal differences. This is the case for ordinary double pipe exchangers, for tubular exchangers where the tube passes equal the shell passes, or where the temperature of one of the fluids remains constant due to change in state such as vaporization or condensation. However, a great many exchangers fail to fall into one of these classes, since the fluids exchange heat while undergoing a combination of concurrent, countercurrent and cross flows. (Figure 2.)

A set of curves published in the *Standards of the Tubular Exchanger Manufacturer's Association* makes possible the evaluation of the necessary correction factors, based on the number of shell and tube passes, and the terminal temperatures. The factor obtained is used as a multiplier for the log mean temperature difference calculated, in the usual manner, from the terminal temperatures. To illustrate the importance of this factor: If the outlet temperatures of the two fluids are equal, the temperature ranges of the two fluids while passing through the exchanger are equal, and the exchanger is of the common type known as a one-two (one shell and two tube passes), the correction factor is approximately 0.80. It can be seen that a factor of such size should certainly not be neglected.

Another consideration in connection with the effective temperature difference is that associated with the use of extended surfaces. In estimating the number of units needed for a particular service, it is easy to forget that the log mean temperature difference calculated from the terminal conditions is not effective over the entire extended area. It is possible to have the temperature at the base of the fin quite a bit different from that at the tip. (Figure 3.) At low over-all transfer rates the conductivity of the metal of the fin is high enough to minimize this effect. But at high transfer rates this effect becomes noticeable and must be taken into account. The amount of the correction is a function of the individual film transfer coefficients and the material of the fins. Several references on this may be found in the literature on heat transfer by extended surfaces.

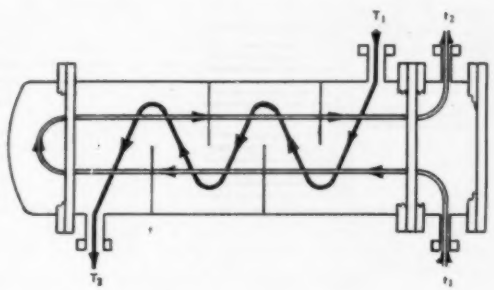


FIGURE 2
Flow in Baffled Exchanger.

Summing up the remarks thus far on the area and temperature difference in an exchanger, it can be appreciated that a certain arrangement is necessary to determine their effectiveness. Neglect in giving sufficient thought to the mechanics of the problem may lead to a poor selection of equipment.

The last of the three factors is the over-all heat transfer coefficient. For preliminary purposes it is general practice to use rates estimated on the basis of experience with similar services, or to apply rates reported in the literature. These reported rates should be used with caution, however, since it is unusual to find qualifying data printed with them. In addition to the mechanical arrangement of the equipment in which they were observed, the pressure drop allowed on the two streams and the amount of fouling are pertinent. High rates are produced by high turbulence in the fluid film. In some cases this turbulence is produced by a phase change such as vaporization or condensation. Otherwise it is necessary to assign a certain amount of energy in the stream, in the form of pressure drop, to the promotion of turbulence. Or, putting it another way, it is necessary to pay for high transfer rates with pressure drop. The fouling factor is of most importance in units in which the fluid film coefficients are high. Addition of these factors is to insure satisfactory operation for a reasonable length of time after initial operation. The listing of the generally accepted factors, as well as much other useful information, is found in the TEMA Standards mentioned before. Where time permits, it is best to calculate the transfer rates by methods found in the standard texts on the subject, and use the published or estimated rates as checks on magnitude. Otherwise, the use of an intelligent "guesstimate" with a suitable margin for error is justified.

Process conditions fix the amount

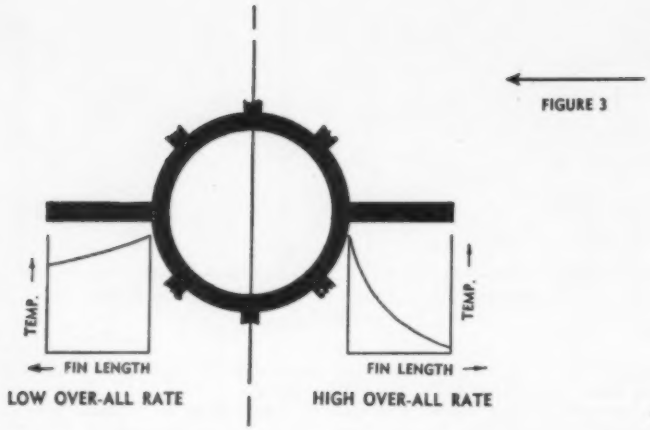


FIGURE 3

of heat to be transferred in a particular unit. The fact that, even in continuous processes, the heat load may vary appreciably over a short length of time indicates the necessity for an overload allowance. Ordinary practice is to design for about ten percent more than the process requirements, with greater allowances made in unusual cases.

If water is one of the fluids in process, good practice dictates some consideration of the maximum allowable outlet temperature in the light of dissolved or suspended material. A maximum of 125° F. where there is appreciable hardness is considered safe. Beyond this point scale will form rapidly and frequent cleaning is required. Also, if there is a cooling tower in the circulating water system it is possible that exposure to higher temperatures may weaken the structure of the wood.

It would be well to point out the waste entailed in having unnecessary temperature crosses in multipass tubular exchangers. A glance at the charts previously mentioned for the correction of the log mean temperature differences will show the rapidity with which this factor falls off with a slight increase in the overlapping of the exit temperatures. This makes necessary the use of several passes on the shell side or the use of several individual exchangers in series. Quite often a little extra thought in choosing stream temperatures during the process design will effect an appreciable saving in exchanger costs by holding these crosses to a minimum.

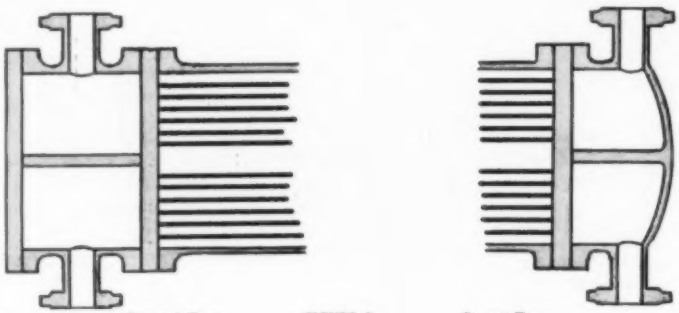
Few General Rules

It is always a problem to decide on which fluid to put through the tubes and which through the shell side of an exchanger. Usually it is a compromise, but a few general rules based on cost of construction and ease of maintenance may be laid down. Usually water is put through the tubes, for two principal reasons. Most water will deposit some scale or sludge, and it is easier to clean the insides of the tubes. Also, it is common practice to use cast iron and admiralty brass in contact with water, due to corrosion considerations. It is cheaper to build the heads of cast iron and the tubes and tube sheets of brass than to use these materials on all shell side parts in contact with the fluid. Condensation of vapors with little liquid sub-cooling is usually done on the shell side. This is to allow the condensed liquid to drip onto the lower tubes and so cause more turbulence on these tubes carrying a heavier liquid load. If a considerable amount of liquid sub-cooling is to be done it is usually better to condense inside vertical tubes if space available will permit. The separate condensing and sub-cooling areas may be calculated, and actually exist as such. Any stream carrying a suspended material should, if possible, be put through the tubes. If put through the shell, the material would tend to settle out in the quiet areas at the base of the baffles. Very viscous materials should be put through the shell side, as the baffles may then be placed very close together to give almost pure cross-flow with the accompanying improvement in transfer rate due to higher turbulence. With two fluids of otherwise similar physical properties, the stream at the highest temperature, highest pressure or highest corrosion potential should be put through the tubes. This will eliminate the need for thicker shells or ones made of expensive alloys.

Mechanical Features

Looking now at the actual construction features of the various parts of a tubular exchanger, consider first the tube bundle. This includes the tube sheets, tubes, cross baffles, tie rods, spacers, impingement plate, longitudinal baffle, channel, channel cover and floating head cover.

It has become almost universal practice in the petroleum industry to use tubes of a few standard sizes. Of these, a length of 16 feet and an outside diameter of ¾ of an inch is most common, with ferrous tubes in 14 and 16-gauge and non-ferrous tubes in 16 and 18-gauge. These sizes give a tube that is not too small to be cleaned by mechanical means and yet has a reasonable ratio of surface to volume. Longer tubes make it more difficult to pull the tube bundle to clean the outside surface or replace a part, while shorter tubes increase the initial cost per square foot of area. Tubes are usually fastened into the tube sheets by rolling, a process whereby the end of the tube is expanded into a hole in the tube sheet. The inside of the tube hole is usually given one or two circular grooves to insure a better seal between the two metal surfaces. Arrange-



Channel Type — FIGURE 4 — Bonnet Type

ments are available which allow the seal to be made by means of a screw thread, a ring of packing and a packing nut. At present these are used principally in power plant installations, but there is a possibility for their use in process plants. The points in favor of an arrangement such as this are the ease in replacing a tube and the fact that the packed joint acts as a means of allowing for the expansion of the tubes. However, there is still the inherent difficulty of a packed joint to partially, at least, offset these advantages.

The choice between floating head and fixed tube sheet construction is not always easily decided. It has become general practice in the petroleum industry to use floating heads almost exclusively. The outsides of the tubes in this type are easily cleaned by pulling the bundle from the shell or, in case of more serious trouble, the entire bundle may be replaced by a standby unit, thereby reducing the down-time considerably. However, this construction is more expensive than the fixed tube sheet type. Another drawback is the difficulty in having more than one pass on the shell side. This springs from the problem in designing a longitudinal baffle of simple construction which will seal tightly against the inside of an unbored shell and still be easily removable. It is for this reason that many designers, when faced with the necessity of using several shell passes on floating head units, prefer to go to several smaller shells in series. Several arrangements for these longitudinal baffles are on the market, but they are not generally used at pressure drops greater than 5 psi. between inlet and outlet shell nozzles.

The fixed tube sheet construction, with or without an expansion joint in the shell, is widely used in the chemical industries and in power plant installations. Its use is justified in the handling of process streams of a non-fouling and non-corrosive nature. The cost of these units is less than the floating head construction and, since the tube bundle cannot be removed, any number of shell passes may be specified by welding the longitudinal baffles into the shell during construction of the unit. The time required for cleaning, replacing or plugging off tubes is about the same for both types of construction.

In some of the older petroleum refineries and in some of the present-day chemical plants it is possible to find fixed tube sheet exchangers with an odd number of tube passes. This arrangement makes it possible for both heads of the exchanger to be of identical construction. This is partly a hold-over from the time when floating heads were still believed to be unreliable and all-welded construction was not general practice. Present-day cost studies show that this construction does not usually effect an appreciable saving, and in some cases increases the associated piping costs.

Wartime Use of U Bundles

During World War II added emphasis was placed on the use of U-tube bundle construction. These had the advantages of cheaper construction and the elimination of the gasketed joint of the floating head. This last feature was particularly desirable in handling corrosive fluids such as hydrofluoric acid, but there were several drawbacks. The minimum radius to which the tubes could be bent made it almost impossible to fill the center lanes and still keep a simple tube arrangement. The tubes were sometimes difficult to clean because of the bends. The greater length of tube required, at a time when most tubing was of a standard 16-foot length, made it necessary to butt-weld before making the bends. And finally, it was difficult to keep spare bends on hand and replace tubes when they failed near the center of the bundle. At the present time the U-tube bundle has its greatest use in reboilers or where an inexpensive unit is desired to handle clean fluids at moderate pressures. In many ways it can be used to fill the gap between the fixed tube sheet and the floating head constructions.

Exchanger heads may be of two types: channels or bonnets. (Figure 4.) The first, and most expensive, is made up of a channel carrying the pass partitions and nozzles, with a separate channel cover plate. The chief advantage of this type is that the channel cover may be removed and the tubes inspected without disturbing the piping connected to the nozzles. Also, with the cover plate removed the channel is lighter and more easily handled for dismantling. The bonnet is a single piece head, either cast or welded, which eliminates the gasketed joint of the channel type and is somewhat less expensive. It is necessary to break the piping connections and remove the entire head to get at the tubes when using this type.

Tubes are arranged according to either of two patterns, called the pitch: triangular (or diamond) or square (Figure 5). In units where little fouling is expected on the shell side the triangular pitch is used, with the long axis of the diamond parallel to the direction of fluid flow, if possible. This is done so that the fluid will have fewer rows of tubes to cross in traversing the shell, with the resultant smaller pressure drop. If appreciable fouling is expected the tubes are laid out on square pitch so the outsides of all the tubes may be reached with the cleaning tools when the bundle is pulled. Another use for square pitch is in reboiler bundles, where the center-to-center distance is a little greater than in the usual bundle. This is to allow more unobstructed passage for the vapors passing up through the bundle and prevent vapor binding of the top tubes. For triangular pitch, the tube spacing is ordinarily 15/16 of an inch with ¾-inch tubes. Occasionally one-inch spacing is used in condensers where the pressure drop is critical. With square pitch a one-inch center distance is ordinarily used, but on reboilers having a high heat flux density the spacing may be increased to one and a quarter inches.

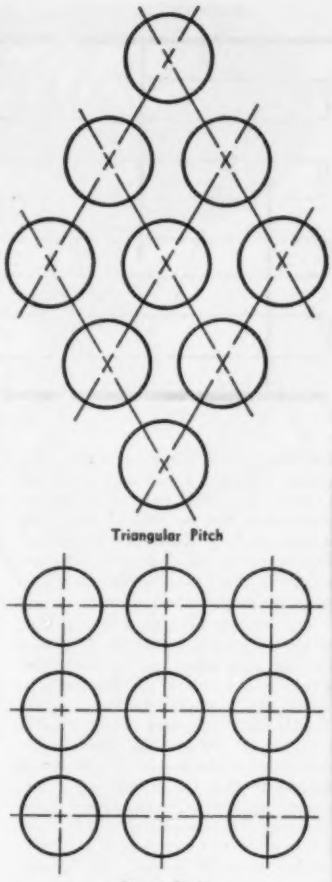


FIGURE 5

The type of baffles to be used is a

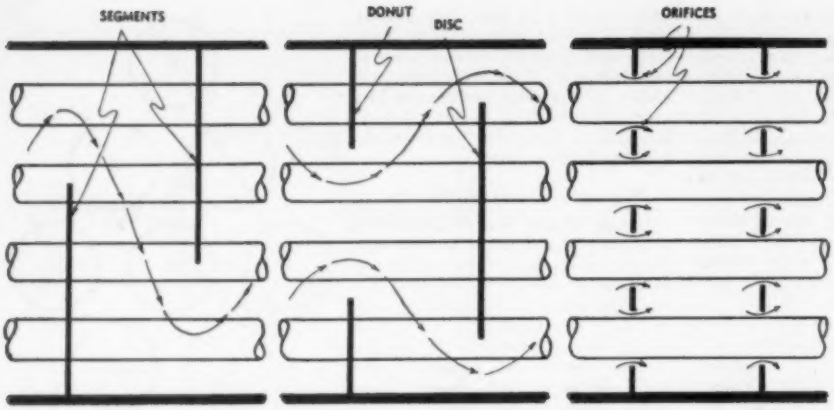


FIGURE 6
Main Types of Baffles

debatable point. The three main types, orifice, disc and donut, and segmental (Figure 6), each have their ardent supporters. But the last of these, the segmental, is probably in widest use. The remarks that follow apply primarily to this type, but they apply in principle to the others as well.

The amount of cross-sectional area of the exchanger, with due allowance for the area taken up by the tubes, which is not cut off by the baffle is called the "percent free area" or the "baffle cut." The most common baffle cuts are 20, 35 and 50 percent. Visualization of the flow in a baffled unit will show that the larger baffle cuts should be used with the larger baffle spacings. In general, the baffles are never spaced closer than 2 inches or farther than 24 inches. Any spacing greater than this is considered to be merely a tube support, and no credit should be allowed for turbulence due to cross flow when the transfer rates are calculated. The varying baffle cuts and distances are used to find the arrangement which will most effectively utilize the allowable pressure drop on the shell side fluid.

Arrangement of Baffles

These baffles may be arranged to give either up-and-down flow or side-to-side flow. Ordinarily, with fluids carrying no suspended material and not passing through a change in state, the flow is up-and-down, parallel to the long axis of the diamond in the triangular pitch. However, if there is any danger of solids settling out or a change in state, side-to-side flow with the largest baffle cut is used. This prevents vapor binding of the top tubes in case of vaporization, or the accumulation of large amounts of liquids or solids on the bottom tubes in case of condensation or settling. When using square pitch there is no difference in the transfer rates or pressure drops between the two directions of flow. But the same precautions must be taken for the instances of vapor, liquid or solid preparation.

Several arrangements have been proposed whereby the outsides of the tubes may be cleaned by means of baffles which are moved back and forth through a mechanism actuated from outside the exchanger. These devices find their greatest usefulness where the fouling is due to a hard friable scale which will easily separate from the tube surface. However, for these arrangements to be effective on soft, porous scale it is necessary that the clearance between the baffle hole and the outside diameter of the tube be very small. This could cause grabbing and scoring of the tubes, and tend to outweigh the advantages of the method.

Many companies require impingement plates under all shell side inlet nozzles. These are good insurance against erosion of non-ferrous tubes at this point. Unfortunately, it is sometimes necessary to sacrifice several of the top tube rows to make room for an adequate plate under a large nozzle. The use of curved plates or shielding tubes, slipped over the regular tubes and held in place under the nozzle, can reduce the loss of area to less than that caused by the use of a flat plate.

In setting up exchanger specifications, it is well to give some thought to requiring several pipe taps in each nozzle. These openings are inexpensive and are very convenient receptacles for thermometer wells or pressure taps should it become necessary or interesting to check the performance of individual units.

Nothing has been said as to the materials of construction to be used, a subject too broad to be covered here. It can be stated that the particular materials used will be a function of the temperature, pressure and corrosiveness of the process streams being handled. In non-corrosive service, for instance, the general temperature limitations are: carbon steel, 1000° F.; cast iron and brass, 400° F. Other materials used will have similar limitations, and these must be given carefulful consideration. Exchangers have been built of almost every construction material by exercise of much imagination and ingenuity. There remain many problems but, judging by past performance of the engineers concerned, there is every reason to believe that they will be solved as they become critical.

Conclusion

It is hoped that the foregoing discussion will serve to emphasize the interdependence of thermal, mechanical and process design in heat transfer work. Since much of the general practice in any one locality is the outgrowth of someone's opinion, an effort has been made to present both the advantages and the disadvantages of optional arrangements. If some seemingly important points have been omitted, it may be attributed to the enormous breadth of the field. For reading, the following are recommended:

McAdams, "Heat Transmission," 2d ed., McGraw-Hill Book Co., Inc., New York, 1942.

Stoever, "Applied Heat Transmission," McGraw-Hill Book Co., Inc., New York, 1941.

Also the transactions of the AIChE and the ASME.

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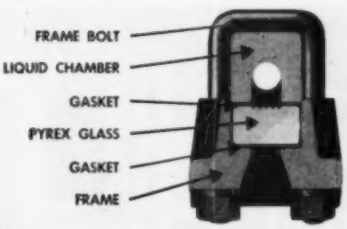

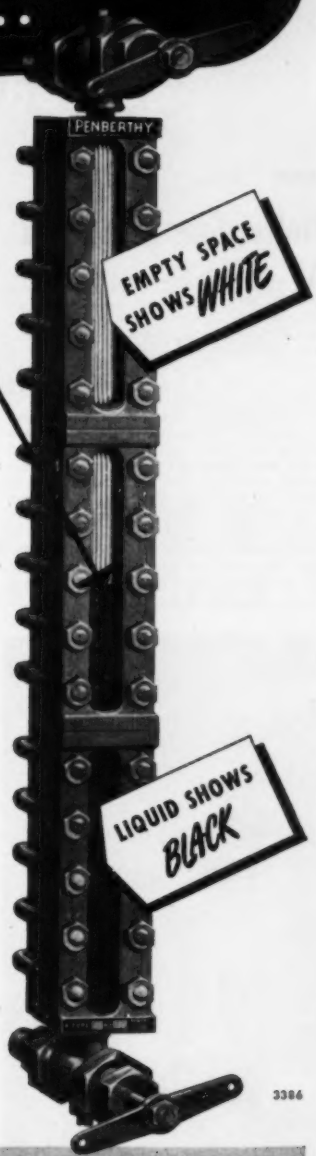

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HOW TO DO IT

HOW TO—

Protect Gate Valve Stems

MANY types of thread protectors have been used on the rising stems of gate valves, ranging from sections of rubber hose to pipe nipples. An improvement in thread protectors is shown in the picture. A pipe nipple of the proper size is closed at the upper end with a welded cap, and the bottom is welded to the retaining nut holding the gate wheel in position. When completed, the protector is partly filled with a soft oil compound especially prepared to prevent metal corrosion and screwed tightly in place on the wheel hub. No grease can leak, nor can sand or dust enter the protector. Each time the gate is closed, the wheel nut wipes the oil from the stem and when opened again, the reservoir of oil quickly covers the threads to keep them in condition that prevents sticking.

HOW TO MAKE—

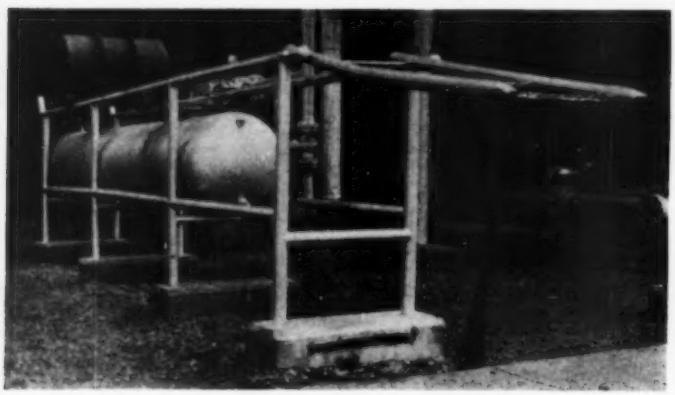
Fire Extinguisher Bracket

A BRACKET for those types of fire extinguishers placed in outside positions can be made by welding a fixed pad to a pipe support column. Such a pad should have a ring attached to prevent slipping. The retainer at the top is a circular cap with a 1-inch ring that drops snugly over the extinguisher and is hinged to the column. By inverting the extinguisher, material inside is prevented from clogging the hose. The hose end is held neatly in place against the support column by a welded wire clip.

HOW TO—

Make Drum Storage Rack

WHEN using a liquid for conditioning cooling tower water, the reservoir can be placed near the installation by building a rack which serves the combined requirements for unloading, storing drums, and and supporting the reservoir for the chemical. The frame is made of 2-inch pipe on concrete piers. Total height matches the average level of a truck body. The reservoir is placed permanently positioned with a filler plug on the upside for emptying drums to replenish the chemical. For handling drums a hinged extension is fitted so that the free end can be placed on a truck bed. Drums can thus be rolled easily from the truck to the storage portion of the rack.



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HOW TO—

Guard Padlocks Better

AN EXPOSED padlock often can be rather easily broken. One plant has devised a scheme for placing padlocks on the inside of doors to plant buildings in such a fashion that they are inaccessible for attack by pry bars or hacksaw, but can be easily opened by key.

As shown, a hole some five inches in diameter is located so that the padlock, when in locked position, hangs on the inside of the door with its lower portion partly across this access opening. The latch can be any of the usual types having staples or other arrangement into which the padlock is inserted for locking purposes. The lock can be easily opened with a properly fitting key. On the other hand, the door latch mechanism and the padlock itself are on the inside of the door, and a prowler, of necessity, must work with one hand through a small opening. If the latch mechanism is heavy and well designed, the prowler's best opportunity would be in breaking the padlock, which, dangling freely, can not be held for best application of tools.

If you do try this scheme, don't drop the key on the inside of the door while the door is still locked.

HOW TO MAKE—

Gauge Level More Visible

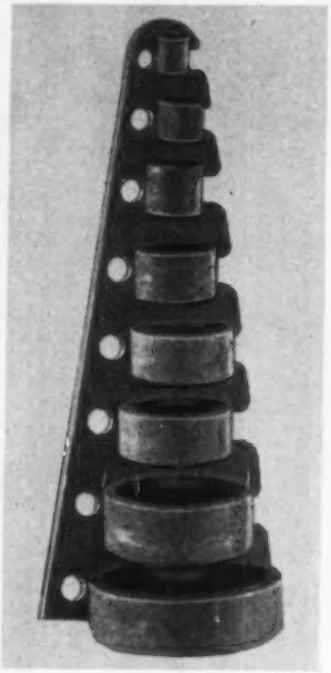
IN VESSELS containing colorless liquids, such as steam boilers or light hydrocarbon processing equipment, operators frequently experience annoyance with conventional tubular gauge glasses through an inability to distinguish easily the indicated liquid level. There frequently is little contrast in the appearance of the liquid and vapor portions of the gauge glasses. The scheme shown here can be used to overcome this difficulty. Dark diagonal stripes are painted or otherwise placed on a light background which is located immediately behind the gauge glass. The appearance of segments of these dark stripes seen through the gauge glass affords a high contrast, both in the apparent width of the stripes and in the extent of their rotation, between the liquid filled and the vapor filled portions of the glass.

This "How to Do It" item is being repeated inasmuch as the picture appeared upside down in the January issue.

HOW TO—

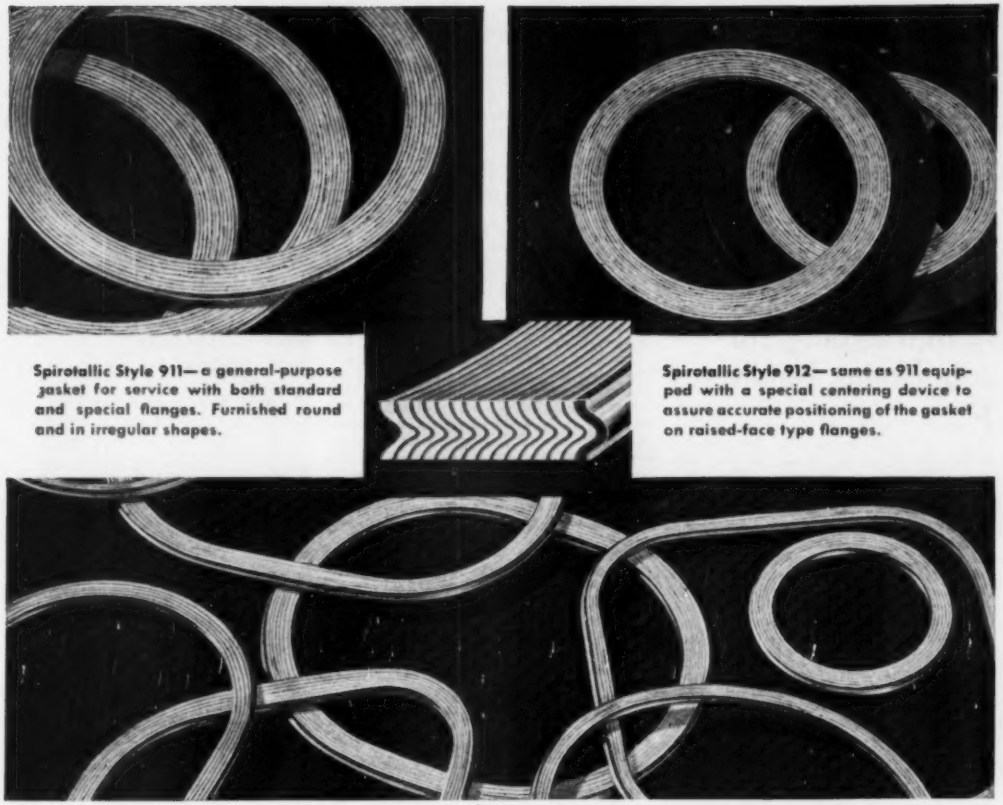
Make Template For Bending U-Bolts

U-BOLTS for pipe line clamps and saddles can be made "one a minute" with an easily constructed template. This template is not difficult to build but some little care should be exercised when laying out and making the various sizes of forms. For each size of U-bolt, there is an individual form which is made by cutting a 2½-inch long ring from extra heavy pipe. The pipe walls must be thick to withstand the strain of bending heavy U-bolts. Each form is fitted with welded flat heads on both sides for additional stiffness. These forms are attached to a thick steel base by welding. Holes are drilled through the steel plate opposite each form while notches are cut on the other side. To make a U-bolt, the steel rod is measured, cut, and threaded on both ends. A nut is run up on one end of the rod when it is passed through the hole at the side of the form. Then, the welder grasps the opposite end of the rod with tongs and progressively heats the rod to bending temperature while it is wrapped over the form until it is shaped as desired.



HOW TO—Make Stand With Long Rollers

MOVING heavy equipment between repair shops and foundation blocks, or elsewhere in the refinery yard, can be accomplished without automotive equipment and much more easily than by makeshift means if this device is used. The stand shown here is made of structural steel angles with a frame-work top and cross braces to produce a rigid assembly. Mounted between each pair of end legs are rollers made of pipe. The axle may be fitted with plain or roller bearings as desired. The advantage of this apparatus lies in its ability to cross surfaces which are dressed with crushed stone, gravel, or shell without miring into soft spots. It likewise rolls easily on concrete floors where seams might interfere with individual caster wheels.



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REFINER AUTHORS and Other Personalities

Information, formal and otherwise, about the men who write for PETROLEUM REFINER as well as others prominent in the industry.

Author Aspires for Job, Home, Family

ERNEST G. LONG, teaching fellow in the chemical engineering department at the University of Texas, Austin, will assist Dr. Kenneth A. Kobe in the preparation of future installments of "Thermochemistry for the Petrochemical Industry," according to an announcement by Dr. Kobe. The first installment of the series, which appeared in the December, 1948, issue of PETROLEUM REFINER, was by Dr. Kobe, who is graduate professor of chemical engineering at the University. Part II, by Kobe and Long, is to be found on page 113 of this number.

Long was born at Hull, Texas, in 1923. He was graduated from high school in Corsicana in 1940, and as ranking male graduate received a two-year scholarship. In 1942 he was graduated from Schriner Institute as class speaker (by scolastic rank).

Entering the University of Texas in 1942, Long received his bachelor of science degree in chemical engineering in 1944 and his master's degree in chemical engineering in 1946. He expects to receive his Ph.D. in chemical engineering in 1949. His first minor is physical chemistry and second minor, mathematics.

ERNEST G. LONG

He is a member of American Chemical Society, Sigma Xi, Omega Chi Epsilon, Phi Lambda Upsilon and Phi Theta Kappa. A research fellowship was awarded to him for 1946-47 from Pan American Refining Corporation, and a Celanese Corporation Fellowship research fellowship in chemical engineering in 1948-49. Long has held a teaching fellowship in chemical engineering since 1944.

Long was married in 1946. His hobby centers on books and research and development in chemical engineering. He says his ambition is a job, a home, and a family. In his opinion, Long says he has been at the University long enough —since he has been long enough to have seniority over 50 percent of the chemical engineering professors there.

Is Paint Technician Even in Own Home

W. B. COOK, author of the article on Gulf Coast refinery painting appearing on page 155 of this issue, is a chemical engineer with Gulf Oil Corporation at its Port Arthur, Texas, refinery. With exception of 3½ years during World War II, while on military leave of absence, he has been continuously employed at Gulf's Port Arthur plant since his graduation from Texas A. & M. College in 1927.

Cook is a native Texan and began his connections with the oil industry during his college days, working one summer in pipe line pump station construction work being done for Magnolia Pipe Line Company and almost a year in the refinery laboratories of Deepwater Refineries, Inc., prior to receiving his B.S. degree.

His employment with Gulf covers several years in the testing and experimental divisions of the Laboratory Department, a portion of which he was general foreman of the experimental laboratory, and several years each as an assistant in the offices of the chief chemist, assistant general superintendent, and general superintendent.

While on military leave during the war, Cook served as a commissioned officer with the Army Service Forces, most of which was on assignment with the Eighth Service Command as Army security inspector of oil refineries and gasoline plants in Texas, Oklahoma, Louisiana, Arkansas, and New Mexico.

After separation from the Army in October, 1945, with the rank of captain,

W. B. COOK

Cook spent several months during the remainder of his military leave assisting his father in law in the operation of his marine shipping agency business in the Port Arthur area before returning to Gulf, when he was shortly afterward given the assignment of technical adviser on paint and painting practices.

Cook owns his home in Port Arthur, and its maintenance upkeep, which naturally includes a considerable amount of "postman's holiday" amateur painting, provides spare time diversion from his refinery duties, although he and Mrs. Cook both enjoy outdoor sports events and other social activities whenever time permits.

Patent Author Now Given Due Attention

STANDBY author of PETROLEUM REFINER'S monthly feature, "Digest of Recent United States Patents Pertaining to Petroleum Refining" (see page 186), is Heinz Heinemann. Incidentally he holds ten United States patents himself.

Project director for Houdry Process Corporation, he is active in research and petroleum refining, particularly in the

HEINZ HEINEMANN

application of adsorbents and catalysts. His entire research career has been chiefly in the field of catalytic refining. Before coming to Houdry, Dr. Heinemann was research chemist and research supervisor with Attapulgus Clay Company, Camden, N. J.

Graduating from the University of Berlin and Technische Hochschule, he received his doctorate at the University of Basle, Switzerland, in 1937. After a year's research work on synthetic fuels at the Frank's Laboratories in Berlin, Dr. Heinemann came to the United States as chief research chemist for Rodessa Oil and Refining Corporation. In 1940 he became research chemist for Danciger Oil and Refining, Inc., and in 1941 he became a research-fellow at Carnegie Institute of Technology, serving as assistant to the late Dr. Ernst Berl. While working on the fellowship, Dr. Heinemann organized the research fellowship of the Dominican Republic.

Author of several technological papers, he also is a member of the American Chemical Society, New York Academy of Sciences, American Society for X-Ray and Electron Diffraction, Schweizerische Chem. Gesellschaft and A.A.A.S.

"Sandy" Doing It Solo This Time

CHARLES (SANDY) SANDERSON, author of the article, "The Selection of Heat Exchangers," is making a solo run in this issue of PETROLEUM REFINER, beginning on page 150. Sanderson, in conjunction with C. C. Lazzari, contributed "The Design of Octagonal Foundations" in December, 1948.

A registered professional engineer in Texas, Sanderson is a partner in a consulting engineering firm in Houston with A. S. Glendening. He was graduated from Drexel Institute of Technology near Philadelphia with a bachelor of science degree in chemical engineering.

Sanderson has been associated with Celanese Corporation of America at Cumberland, Md., in the cellulose acetate research and development and in the petroleum chemicals division. He has worked in the heat exchanger division of the Lummus Company as design engineer and did field engineering work during initial operation of aviation gasoline and synthetic rubber plants. He later was with Petroleum Engineering, Inc., as process engineer concerned with natural gasoline and cycling plants.

Ph.D. Degree Soon

He was awarded the Gulf Oil Corporation Graduate Fellowship in 1946 at Texas A. & M., where he assisted C. G. Kirkbride in consulting work on economic process evaluations of government-owned synthetic rubber and aviation gasoline plants. He completed a minor in mechanical engineering and received his master's degree in chemical engineering. He expects to receive his Ph.D. degree in chemical engineering during the next few months.

Hobby Utilized To Illustrate Refiner Article

MILTON LUDWIG, engineer of Standard Oil Company of California, reports on a recent job accomplished by the engineering department under the title of "Field Stress Relief of Vessels by Radiant Electric Heating." (See page 109.) This article is a description of a new method of heating for stress relief successfully applied to two large reactor vessels in Standard's refinery at Richmond.

Ludwig has been employed by the engineering department of Standard since 1934, when he was graduated from Stanford University. He was given a leave of absence from 1941 to 1942 to teach in the mechanical engineering department of the University of California.

Despite the fact that he was graduated in electrical engineering at Stanford University, most of Ludwig's work has been with fluid mechanics, heat transfer, pipe line and pressure vessel design, and special stress-analysis problems. One of the problems he helped on was the development of design details for the above-ground portion of the Trans-Arabian pipe line. He also was job engineer for the design of a 35-mile, 66-kv. electrical transmission line in Arabia several years ago.

Ludwig's hobby is photography. One of the photographs used in illustrating his article he made from a 35 mm. negative. This job of enlarging brought forth the remark that photography in this connection is a minor hobby. At least, he says, "I often do better with pictures of my wife and children. It is possible that the subject has something to do with it." The Ludwigs' two boys are nearing the ages of 5 and 7.

President-Elect of SAE Writes On Future Fuel Sources

R. J. S. PIGOTT, author of the article dealing with future fuel or power sources (page 87), has been chief engineer of Gulf Research Development since 1929. After graduation from Columbia University in 1906 with a degree in mechanical engineering, he engaged in power-industry installing of low-pressure turbines and other equipment, and in the reconstruction of several electric power generating plants in the East and Middle West. Post-graduate work by Pigott was limited to one year at Columbia as professor of steam engineering.

Varied Experience

During the five years from 1915-20, he worked as consulting engineer in the construction of power and service equipment for Remington Arms, superintendent of mills for Bridgeport Brass Company, and works manager of Crosby Steam Gage and Valve Company. He returned to the power industry in 1922 as mechanical engineer at Stevens and Wood; later he worked for Public Service Production Company, designing and constructing large power plants. Since 1929, Pigott has been chief engineer in charge of engineering research for Gulf Oil Corporation and its subsidiaries.

Pigott has obtained about 30 patents on power-plant equipment—oil burners, meters, test equipment, and pumps.

He was chairman of the ASME special research committee on Fluid Meters from 1916 to 1946, and from 1918 to 1946, he was a member of ASME main

MILTON LUDWIG

power test codes subcommittee. Pigott was the first president of the former American Society for Measurement and Control (now Pittsburgh Chapter of the Instrument Society of America). He is SAE president-elect.

Pigott has written and published more than 40 technical papers on power plant design, fluid flow, instruments, lubrication, fuel and lubrication system in aviation, and superchargers.

C. D. GARD

Quiet, Friendly, Capable, Efficient

C. D. GARD, chief process engineer, field department, Union Oil Company of California, prepared the article beginning on page 117 of this issue, entitled "Dry Ice Manufactured From CO_2 Extracted From Natural Gas." He has been with Union since 1921, starting in charge of experimental work for the extraction of gasoline from natural gas. Quiet and friendly, Gard is an entirely capable and efficient engineer, who has been active in the engineering, development, and supervision of construction and operation of natural gasoline and natural gas processing facilities since he joined the company. He is a graduate of the University of Southern California, 1917, in electrical engineering.

Active in NGAA

Gard also has been active in technical committee work with the Natural Gasoline Association of America, the American Petroleum Institute, and the California Natural Gasoline Association which he joined within two months of its organization in June, 1926. He has served in the latter as chairman of the technical committee, vice president, and president.

Lifts Group from Rut

ELBERT R. SITTON, enthusiastic insulation expert and author of "Expansion Problems in the Heat Insulation of Process Vessels" (see page 131), rates a most unique place in the PETROLEUM REFINER family of authors. According to Sitton, the "family" has been "following a fixed pattern of universities and degrees." The school days he remembers best were spent in skipping early morning classes at old Port Arthur High School when the trout were schooling in Sabine Lake. As a result of this "schooling" he earned several degrees including the O.F.W.S. (Old Fashioned Wood Shed) and L.C.T. (Local Constable's Third). He is convinced that joining the PR family with his educational background will certainly lift it out of the rut.

Sitton, a friendly, hard-working and fun-loving fisherman from Port Arthur, grew tired of a diet of Sabine Lake trout in 1918; consequently, he landed a job in The Texas Company refinery in the insulation department. He has not admitted that in those days insulation work in a refinery was the easiest outdoor work available.

But once in insulation—always in insulation. Sitton has worked with just about all of the commercial types of insulating materials developed during the past 30 years; that is with the exception of the two years he spent in the Marine Corps during World War I. He was sales engineer for Mundet Cork Corporation of Houston from 1934 to 1940. In 1940 he left to take charge of the insulation department for Consolidated Shipbuilding Corporation at Orange, Texas. During the evenings on this job, Sitton taught blueprint reading and ship's structure.

After the war he came back to Houston and joined the B. & B. Engineering & Supply as sales engineer doing estimating, selling, and specification writing. He left B. & B. last year to enter business for himself. A member of the American Society of Heating and Ventilating Engineers, Sitton also has been a member of the Asbestos Workers Local No. 22 for 29 years.

His chief hobby is working with hook, line, and sinker, and believe it or not, but on days and evenings not suited for Waltonians, he plays 8-ball with the boys at the Elks' Club in Houston.

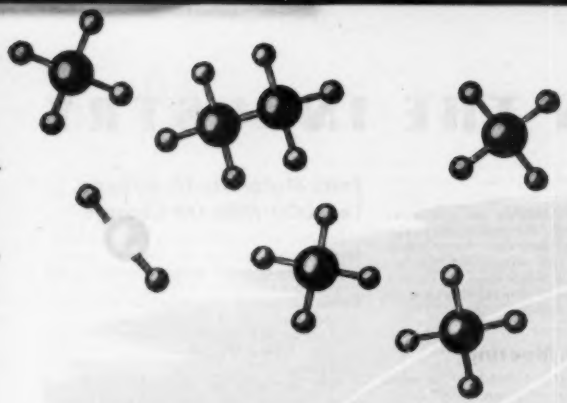
Sitton's favorite food was and is FISH . . . boiled flounder with wine sauce.

His complaint—flounders are smaller today than yesteryear.

ELBERT R. SITTON

Socony-Vacuum Veteran Retires

H. B. Malone, superintendent of the Pratt Works of Socony-Vacuum Oil Company, Inc., since 1927, is receiving a 45-year service button from the company before he retired on January 1, 1949. At the presentation were, left to right, A. L. Kothe, processing department foreman of the Pratt Works; E. J. Tully, grease and compounding superintendent of the Pratt Works; D. L. Hooker, in charge of Eastern refineries; Malone; W. F. Burt, vice president and director; Dr. W. L. Linton, manager of the company's East River refinery operations; E. F. Pinney, superintendent of the Pratt Works, succeeding Malone; and William Ruchstuhl, foreman of the candle department of the Pratt Works.



SULPHUR

FROM SOUR NATURAL GAS

THE McKee organization has undertaken design engineering and construction of a plant for the manufacture of 150 tons per day of sulphur from sour natural gas.

This plant, when completed, will serve the dual purpose of conserving waste material and eliminating air pollution.

ARTHUR G. McKEE & COMPANY

DESIGN, ENGINEERING AND CONSTRUCTION FOR THE PETROLEUM REFINING AND IRON AND STEEL INDUSTRIES

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THE MONTH IN THE INDUSTRY

"Monopolistic Practices" Of Oil Industry Flayed

To correct what it considers "monopolistic practices" in the petroleum industry, the Senate Small Business Committee has filed its report which recommends:

Separation of crude and products pipe lines from "shipper-owners"; study of natural gas wastage; "reestablishment" of competition between oil producing states; examination of the operation of the Interstate Oil Compact Commission with the possibility of either repealing the federal law or making amendments with the view of helping to safeguard public interests; investigation of the Connally Hot-Oil Act with the view of either repealing it or imposing restrictions that will make it applicable only when oil-producing states follow sound engineering principles of conserving oil and making it necessary if they are held down to market demand; delay in the construction of the Trans-Arabian pipe line until the domestic supply of steel has become greater than the demand; and the prohibition of monthly forecasts of crude petroleum demand by the Bureau of Mines.

Three oil-divorcement bills have been introduced in Congress by Senator Gillette (Democrat, Iowa). The bills would "prohibit interstate common-carrier pipe lines from transporting commodities in which such carriers have any interest, divorce the business of producing, refining and transporting of petroleum products from that of marketing petroleum products, and prohibit producers, refiners and marketers of petroleum products from operating tankers and barges."

Tax Change Suggested

Claiming that the present tax system does not take into consideration the rising price of equipment, Admiral Ben Moreell, president of Jones and Laughlin Steel Corporation, has proposed a change in the federal tax law which would allow companies to write off a portion up to one-half of equipment costs within one to five years, and allowing the companies to deduct this amortization from taxable income. He suggests that the measure might be effective only as long as companies were modernizing and increasing capacity.

Science Foundation Bill

Congress again will consider creation of a national science foundation.

Proposed by President Truman the measure would set up a science foundation of 24 members for six-year terms with the president naming the foundation director. He has asked for a direct appropriation of $2½ million plus $12½ million in contract authorizations, thereby enabling the foundation to establish its organization and initiate a program.

Struth Joins API

H. J. Struth, veteran oil economist and analyst, has joined the American Petroleum Institute staff in New York as head of the Research Section in the Department of Information. He resigned the editorship of the Petroleum Data Book, Dallas, to accept the post.

Prior to his editorship of the data book, Struth spent 10 years with the Mid-Continent Oil and Gas Association as an economist and administrative assistant. During the NRA days he served in Washington as technical adviser to the Petroleum Administration.

Oil Compact Meeting

The Interstate Oil Compact Commission will hold its spring quarterly meeting May 10-12 at the Roosevelt Hotel in Jacksonville, Fla.

Calendar of Meetings

FEB. 1949	
13–17	American Institute of Mining and Metallurgical Engineers, Annual Meeting, San Francisco, Fairmont Hotel.
21–23	API Lubrication Committee Meeting, St. Louis, Jefferson Hotel.
28 to Mar. 4	American Society for Testing Materials, Spring Meeting and ASTM Committe Week, Chicago, Hotel Edgewater Beach.
MAR.	
1– 2	Wisconsin Petroleum Association, Annual Convention, Milwaukee, Schroeder Hotel.
6–10	American Institute of Chemical Engineers, Regional Meeting, Los Angeles.
7–10	Manufacturers Standardization Society of the Valve and Fittings Industry, New York, Commodore Hotel.
7–10	National Association of Corrosion Engineers, Annual Convention, Cincinnati.
14–17	Chicago Technical Societies Council, Annual Chicago Production Show, Chicago, Hotel Stevens.
24–25	New England Gas Association, Boston, Statler Hotel.
27 to April 1	American Chemical Society, Division of Petroleum Chemistry, Spring Meeting, San Francisco.
28–30	Western Petroleum Refiners Association, San Antonio, Plaza Hotel.
29 to April 1	Nineteenth Annual Safety Association, Boston, Statler Hotel.
APRIL	
4– 5	Industrial Accident Prevention Association, Toronto, Canada, Royal York Hotel.
4– 7	American Petroleum Institute, Refining Division, Mid-Year Meeting, Houston, Shamrock Hotel.
11–12	American Institute of Electrical Engineers, New York, Statler Hotel.
11–13	Midwest Gas Association, Annual Convention, Des Moines, Hotel Ford Des Moines.
11–13	American Society of Lubrication Engineers, Annual Meeting, New York, Pennsylvania Hotel.
11–13	National Association of Corrosion Engineers, Cincinnati, Netherlands-Plaza Hotel.
11–15	Western Metal Congress and Exposition, Los Angeles, Shrine Civic Auditorium.
12–14	Southwestern Gas Measurement Short Course, Norman, University of Oklahoma.
13–15	National Petroleum Association, Cleveland, Hotel Cleveland.
18–20	Midwest Power Conference, Annual Meeting, Chicago, Hotel Sherman.
20–22	Southern Gas Association, Annual Convention, Biloxi, Buena Vista Hotel.
20–22	Natural Gasoline Association of America, Fort Worth, Texas Hotel.
28	Society of Automotive Engineers, New York, Engineering Societies Building.

Tells Motorists To Adhere To 1000-Mile Oil Change

In answer to the recent recommendation of the Bureau of Federal Supply for a 4000-mile oil change "under controlled preventative maintenance," A. C. Pilger, Jr., field engineer for Tidewater Associated Oil Company, has stated that motorists should continue to adhere to the 1000-mille oil change for safe operation.

Safe levels of oil change periods are determined by the controlling factors of maintenance, type of motor oil, type of gasoline, engine design and type of operation, and in order to extend the oil change period a qualified engineer would be required who is familiar with all factors governing operation of the vehicle, Pilger added. Only where an engineer is supervising controlled preventive maintenance should oil change periods be extended, he declared.

Improvements Reduce Cost Of Coal Synthesis Plant

Improvements in equipment design and the modification of some of the processes have reduced the construction and gasoline manufacturing cost in a 30,000-barrel daily coal hydrogenation plant. The Bureau of Mines in its latest circular estimates the cost of building the coal-to-oil plant at $244 million with the tested innovations and about 25 percent higher without them. Gasoline manufacturing costs are estimated at 14.3 cents per gallon. This figure does not include revenue from by-products, return on investment or sales expenses. A flow sheet of both the liquid and vapor phases of coal hydrogenation and a general description of the hydrogenation process are included.

For a copy of circular 7486, "Improvements in Hydrogenation of Coal," write Bureau of Mines, Publication Distribution Section, 4800 Forbes Street, Pittsburgh 13.

Cities Service Names Lynd

Lloyd Lynd has been named a vice president of Cities Service Oil Company (Delaware). Before his recent appointment Lynd was treasurer and director of Cities Service Oil Company, Empire Pipeline Company, Cities Production Corporation and Terminal Facilities, Inc., as well as a director and assistant treasurer of Cities Service Oil Company, Ltd.

Engineers' Council Meets

The Engineers' Council of Houston will hold its second annual symposium April 2 at the Rice Hotel in Houston. National authorities will present five papers on the major phases of "The Conservation of Our Natural Resources," subject for the symposium.

CORRECTION

In the article, "Pressure-Temperature Correlations for Petroleum and Hydrocarbons" by Matthew Van Winkle, associate professor of chemical engineering at the University of Texas, which appeared in the January, 1949, issue of

THE MONTH...

PETROLEUM REFINER, "Figure 1" on page 88 should have been labeled Figure 2, and "Figure 2" on page 90 should have been labeled Figure 1.

Esso Standard Promotes 4 In Baton Rouge Refinery

M. W. Boyer, vice president of Esso Standard Oil Company and general manager of its Baton Rouge refinery, has been placed in charge of all manufacturing operations of the company effective February 1. His headquarters will be in New York.

Cecil Morgan, associate general counsel of the company, has been named a vice president and will assume charge of manufacturing, public relations and crude oil purchasing operations of the Louisiana division, succeeding Boyer.

H. J. Voorhies, assistant general manager of the Baton Rouge refinery, will become general manager.

H. G. Mangelsdorf, assistant to the general manager, will become assistant general manager, succeeding Voorhies.

API Lubrication Group To Meet In St. Louis

Seven speakers for the American Petroleum Institute's Lubrication Committee meeting, Jefferson Hotel, St. Louis, February 21-23, the first of four to be held throughout the year, have been announced as follows:

February 23 a.m.—W. H. Oldacre, D. A. Stuart Oil Company, Ltd., Chicago, "Cutting Fluids—An Engineering Responsibility and a Marketing Opportunity;" F. H. Ott, Union Oil Company of California, Los Angeles, "Modern Greases Mean Simplified Lubrication;" J. C. Nourse and C. McKee, Nourse Oil Company, Kansas City, Mo. (subject to be announced); H. L. Moir, The Pure Oil Company, Chicago, "Power Transmission Fluids—A Challenge to the Service Station."

Afternoon: T. P. Sands, Monsanto Chemical Company, St. Louis, "Present-day Automotive Gear Oils;" E. H. Erck, Pioneer Eclipse Division, Bendix Aviation Corporation, Teterboro, N. J., "A Consumer's Appraisal of Technical Petroleum Training Programs;" and John Boyd, Westinghouse Corporation, Research Laboratories, East Pittsburgh, Pa., "A Consumer's Goals in Lubrication."

Two more speakers for the afternoon session will be announced later by Chairman Dayton P. Clark, Gulf Oil Corporation.

S. W. Sparrow Heads SAE

Stanwood W. Sparrow has been elected president of the Society of Automotive Engineers for 1948. He is vice president in charge of engineering of Studebaker Corporation, South Bend, Ind.

Among the vice presidents elected to serve with Sparrow are Max M. Roensch, research coordinator of Ethyl Corporation, and H. L. Moir, technical advisor for Pure Oil Company.

Crude Oil Throughput of the Operable Refining Capacity of the United States (Barrels Per Calendar Day)

(Report of Committee on Refining Capacity—National Petroleum Council)
January 13, 1949

REFINING DISTRICTS[1]	Reported Actual	ESTIMATED:—			
	September 30, 1948	December 31, 1948	March 31, 1949	June 30, 1949	September 30, 1949	December 31, 1949
I. East Coast	923,100	923,100	942,100	975,100	1,015,100	1,030,100
Appalachian No. 1	116,200	117,700	118,000	118,000	118,000	118,000
II. Appalachian No. 2	71,500	71,500	75,000	80,000	80,000	80,000
Indiana, Illinois, Kentucky	1,021,900	1,067,500	1,079,700	1,095,200	1,102,600	1,115,800
Oklahoma, Kansas, Missouri	512,900	498,500	495,800	497,700	522,100	531,000
III. Inland Texas	294,700	292,500	290,000	289,000	287,000	269,900
Texas Gulf	1,531,000	1,559,500	1,581,500	1,581,500	1,581,500	1,581,500
Louisiana Gulf	450,100	456,600	458,100	458,100	458,100	458,100
North Louisiana-Arkansas	94,900	94,900	95,700	95,700	95,700	95,700
Rocky Mountain, New Mexico	15,000	15,000	15,000	15,000	15,000	15,000
IV. Other Rocky Mountain	185,500	203,900	201,300	205,200	220,300	221,000
V. California	1,044,800	1,046,300	1,052,300	1,057,300	1,059,300	1,059,300
Total United States	6,261,600	6,346,900	6,410,500	6,467,800	6,534,700	6,569,400

NOTE: In addition to the above, there were on September 30, 1948 about 28,000 barrels daily capacity shut down which would need major repairs before it could be operated.

[1] These are the general supply and demand areas of the country, and are the same as the wartime PAW districts.

Total U. S. Refining Capacity Estimated At 6,346,900 Barrels in NPC Survey

The National Petroleum Council's Committee on Petroleum Capacity last month reported that expansion of refining capacity for the production of gasoline, fuel oil and other petroleum products in the United States has, in the past two years, exceeded all expectations, with surplus capacity running approximately 10 percent above recent peak production requirements.

Walter S. Hallahan, chairman of NPC, said that the data which had been compiled at the request of the Department of the Interior, is further evidence of the remarkable accomplishment of the petroleum industry in expanding its capacity so rapidly during a period of steel and manpower shortage. Supplies of petroleum products now available for our military, civilian and industrial requirements are greater than in any previous winter, exceeding wartime highs.

The committee was headed by Dr. Robert E. Wilson, Standard Oil Company (Indiana) board chairman.

Estimated daily refining capacity of the operable refining units of the U. S. as of December 31, 1948, totaled 6,346,900 barrels. A previous council report showed March 31, 1947, total refining capacity at 5,588,402, an increase of 14 percent in 21 months. Estimated additions in 1949 will add another 3½ percent to the December, 1948, figure.

A study of the daily average refining capacity and runs to stills in the U. S. reveals the excess or surplus refining capacity which has been available since 1917. Although the trend has been sharply upward in both refining capacity and actual runs to stills, the gap between capacity and runs has steadily narrowed since 1932 resulting in the smallest surplus of refining capacity at the present time that the country has ever had—approximately 10 percent.

Dr. Wilson emphasized a difference which is often not recognized. "Most concerns," he said, "feel that they get the lowest average cost when they operate at 100 percent of capacity, but when you have material of widely varying ages and efficiencies, that is not true. I am confident that to go above 90 percent in our industry, realizing the the type of units we have brought into operation, we would increase rather than decrease average costs."

"Refinery capacity has increased during the past two years at an unprecedented rate, and the margin of about 10 percent of further operating capacity over crude runs, is still available," Dr. Wilson said. "This was done very largely by the $5 billion that the oil industry invested in expansion of facilities. If we had had an excess profits tax during that period it could not have been done."

The following are estimates of the oil charging capacity per calendar day (barrels daily) of the operable refining units in the U. S., beginning September, 1948, by quarters through the year 1949:

Actual September 30, 1948	6,261,600
Estimated December 31, 1948	6,346,900
Estimated March 31, 1949	6,410,500
Estimated June 30, 1949	6,467,800
Estimated September 30, 1949	6,534,700
Estimated December 31, 1949	6,569,400

Note: In addition to the above, there were on September 30, 1948, about 28,000 barrels daily capacity shutdown which would need major repairs before it could be operated.

The committee did not undertake to classify refining capacity into "economic" and "uneconomic" as requested.

The much higher capacity figure, 1948 over 1947, resulted from the pressure for increased products which brought about not only much new construction but also the adoption of many expedients which increase capacity or decrease shutdown time, the report said. Figures for December indicate U. S. refineries were operating at 90.6 percent of capacity of the estimated December 31 capacity.

H. J. Holcomb to New York

H. J. Holcomb, formerly in the process engineering department of the Augusta, Kans., refinery of Socony-Vacuum Oil Company, Inc., has been transferred to the company's pipe line department in New York.

A graduate of Oklahoma A. & M., Holcomb started with Socony-Vacuum 20 years ago. He was transferred in

THE MONTH...

1939 to Augusta from the company's refinery at Casper, Wyo. Holcomb was in the U. S. Army from June 30, 1941, until May 1, 1945, when he was discharged as a major.

Oronite Offers New Line Of Lubricating Additives

An extensive line of lubricating oil additives is being manufactured and sold by Oronite Chemical Company, Standard Oil Company of California subsidiary, effective January 1, 1949.

The additives will be available as finished concentrates, ready for blending with base stocks to produce high grade diesel and motor lubricants and as individual chemical compounds for use as lubricating oil detergents, antioxidants, corrosion inhibitors and similar products.

I. M. Hemphill Retires After 34 Years With Shell

When I. M. Hemphill, manager of the Martinez refinery of Shell Oil Company, retired December 31 he closed a 34-year record of service. He will be succeeded by J. A. Tench who has been superintendent of the plant for the past two years. Dr. R. C. Barton will be transferred from Shell's Wilmington refinery to fill the vacancy created by Tench's promotion.

Dr. Warren Lewis Selected To Receive AIC Gold Medal

Dr. Warren K. Lewis, emeritus professor of chemical engineering at the Massachusetts Institute of Technology, has been unanimously selected to receive the 1949 gold medal of The American Institute of Chemists. Charles Allen Thomas of Monsanto Chemical Company received the medal last year.

The award is made "in recognition of Dr. Lewis' administrative ability, leadership, and outstanding success as a teacher. He is also noted for his contributions to research, particularly in the fields of petroleum and leather manufacture.

Presentation of the medal will be made at the annual meeting of the institute, to be held in Chicago, May 6-7.

William Schwarz Is Caltex European General Manager

William Schwarz has been appointed to the newly created position of general manager for Europe by California-Texas Oil Company, Ltd. He will maintain offices in Paris where he will supervise the European refinery construction program.

Phenol Facilities Expanded

The Dow Chemical Company, Midland, Mich., has completed the facilities which will expand its phenol capacity by 30 million pounds per year.

Instituting the manufacture of synthetic phenol in this company in 1915, Dow supplies the chemical for the production of phenolic plastics, plywood bonding agents and other adhesives, protective coatings and in oil refining.

Shell Oil Decentralizes Gas-Gasoline Activities

Church

Jordan

George T. Tennison has been named regional gas manager to coordinate the gas activities of Shell Oil Company's four areas east of the Rocky Mountains and will be assisted by Ed S. Quinn, regional gas representative, coordinating gas contracts and measurements; and by John B. Haefer, Jr., regional gas representative, handling purchases and sales of volatiles.

Tennison

Gasoline and cycling plant design and construction are centered in the engineering division of the regional production department. The gas engineering section, headed by Merle R. Church, regional gas engineer, will deal with the construction of plants, while the technological section, headed by John T. Jordan, regional technologist, will deal with the design of such plants.

Continental Expands Its Engineering Department

Continental Oil Company has expanded its general engineering department with the appointment of J. H. Olehy, formerly director of technical services in the company's manufacturing department, as manager of the enlarged department.

M. E. Clawson, chief for the past 13 years, will continue as chief construction engineer, and T. O. Duller, formerly assistant chief engineer, has been appointed chief design engineer.

Nuclear Fission Use Would Improve Fuels, Lubricants

Nuclear fission is being used in improvement work on automotive fuels and lubricants, according to California Research Corporation, Standard Oil Company of California research organization.

The new method involves the use of radioactive piston rings in test engines, the results of which probably will be expressed in longer engine life and reduced maintenance from less engine wear. In the test a radioactive piston ring is installed and the engine run for three or four hours. Then, a sample of oil is taken from the crankcase and tested with a Geiger counter, which immediately indicates the amount of metal worn from the activated ring. The minute particles of iron are flushed away by the oil. As little as one-millionth of an ounce of metal worn from the rings can be detected.

Other uses of radioactive substances revealed by the research corporation, which has worked closely with the Atomic Energy Commission, involves tracing of oil shipments through miles of pipe line. One-billionth of an ounce of radioactive Barium is placed in an oil sample, and the progress of the sample followed with a Geiger counter.

Radioactive carbon is being used in a similar method to learn more about what happens to gasoline molecules as they pass through the operation of a modern refinery.

John C. Bolinger Dies

John C. Bolinger, 56, process design engineer for General Petroleum Corporation, died January 17 in Pasadena, Calif. He contributed to the design of many of the distillation units of the company's refinery at Torrance, Calif., as well as aiding in the development of its TCC units and the adaptation of the TCC processes and products to local conditions.

Associated with General Petroleum since August, 1926, Bolinger was a graduate of the University of California and was a member of the California Natural Gasoline Association.

SAE Chairman Retires

E. W. Upham, chairman of the fuels and lubricants committee of the Society of Automotive Engineers for 20 years, has retired from office and will be succeeded by M. D. Gjerde.

Kellogg Presents Review Of World Refining Setup

Construction of four refineries in South America with still others projected are set forth in a "Global Review of Oil Refining in 1949" prepared by the M. W. Kellogg Company. Activities in Europe also are touched upon.

Argentina, with three refineries now being built, is seeking to "refine her own oil in her own plants," the largest of which, near Buenos Aires, "will have facilities comparable with the most advanced in the world." The three-plant program includes delayed coking, fluid catalytic cracking, catalytic polymerization and alkylation.

Brazil, with no complete refinery, is having constructed a 2500-barrel daily complete refinery at Bahia, its nucleus being a thermal cracking combination unit.

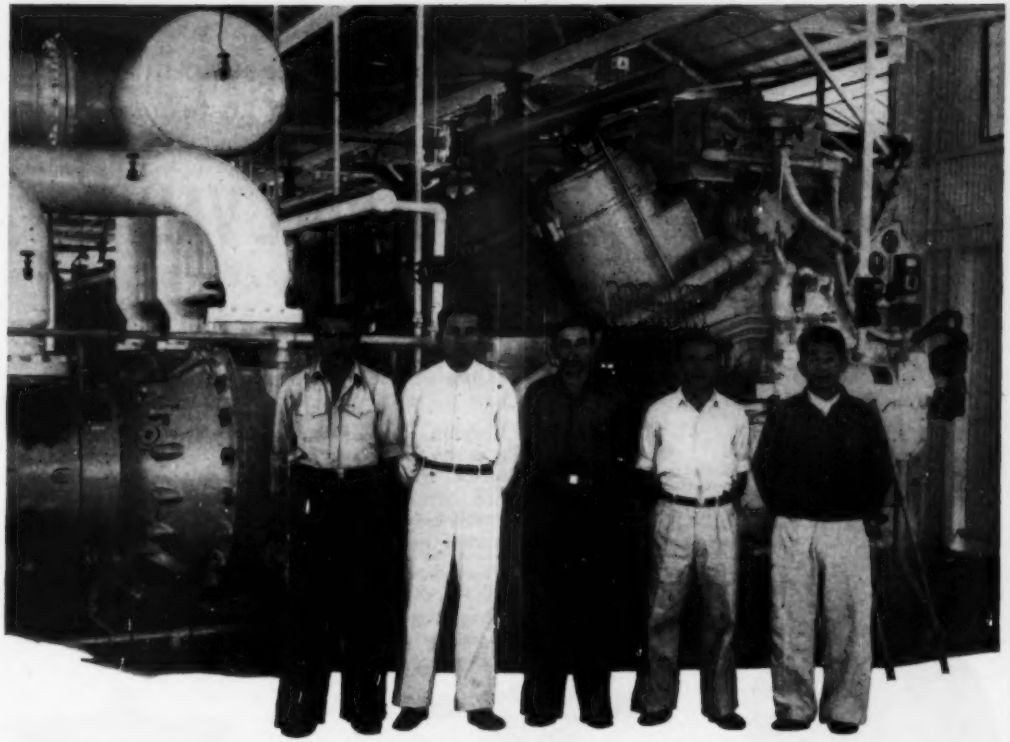
Chile is planning a refinery to process Tierra Del Fuego production, now 2000 barrels daily.

Kellogg also reported it is participating in the current Venezuelan refinery expansion where "many big companies are pouring millions of dollars" into drilling and refinery construction.

Three of Canada's largest oil companies "now operate or are building Fluid cat-crackers," these all in the Montreal area.

In Europe "refineries are geared to produce a 30 percent gasoline yield of 70 ASTM octane at the pump instead of the American 45-50 percent yield of 75 to 80 octane rating. At present, regular grades of gasoline in Europe range all the way from 70 octane to the low 60's.

"European refineries are currently un-



These men can give you a tip on engine performance unexcelled!

IF YOU asked these five operators for some good advice on how to get top reliability, efficiency and economy in big engine performance, they would doubtless suggest that you specify Cooper-Bessemers. They have reason to know.

Here, in an important South American plant, power for driving pumps, generators and compressors is furnished by nine 600 hp Cooper-Bessemer GMV gas engines. And here, these men have adopted some mighty high operating standards that have become a slogan: "110% capacity . . . 99% running time . . . 4,000 hp hours per gallon of lube oil." This is just another example of how capable operators and Cooper-Bessemer quality can always get together for truly outstanding performance, month after month and year after year.

Today there are rugged Cooper-Bessemers to meet virtually all heavy duty requirements over 25 horsepower — efficient, long-lived gas engines, engine-driven compressors and Diesels of many types and sizes. You can be sure of engine performance at its finest when you choose Cooper-Bessemers.

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1. Is this an au-to-mo-bile?
Yes, this is an au-to-mo-bile.
It is a fine au-to-mo-bile and

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helped to make every part of it.

American Industry has gone a long way since McGuffey compiled his First Reader in 1836. But Powell Valves have matched every step in its progress.

Literally, Powell Valves help to make everything that goes into the modern automobile. Because, whether it be motor, transmission, chassis, body, plastics, finishes, tires, anti-freeze, battery, gasoline or any other processed item, there are Powell Valves exactly suited to control the flow of all media used in their production.

This automobile merely illustrates the completeness of the Powell Line. The important point is that, no matter what *your* product may be, there are Powell Valves especially adapted for each and every one of your flow control services.

Fig. 1793—Large 125-pound Iron Body Bronze Mounted Gate Valve. Made in sizes 2" to 30", inclusive. Has outside screw rising stem, bolted flanged yoke and tapered solid wedge. Also available in All Iron for process lines.

Fig. 3061—Class 300-pound Cast Steel Swing Check Valve with bolted cap and flanged ends. Disc has ample lift to permit full, straightway, unobstructed flow through the valve body.

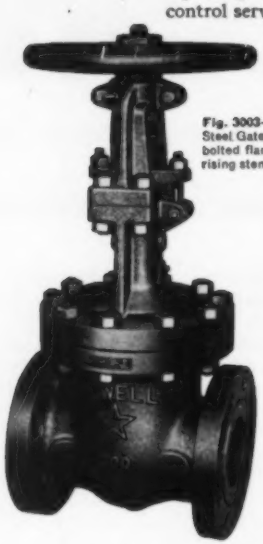

Fig. 3003—Class 300-pound Cast Steel Gate Valve with flanged ends, bolted flanged yoke, outside screw rising stem, tapered solid wedge.

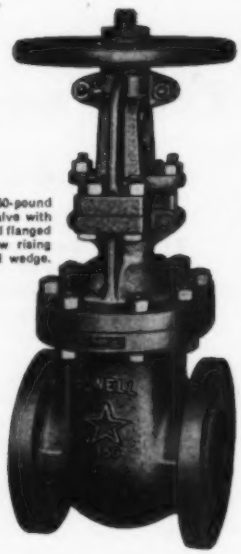

Fig. 1503—Class 150-pound Cast Steel Gate Valve with flanged ends, bolted flanged yoke, outside screw rising stem, tapered solid wedge.

The Wm. Powell Co., Cincinnati 22, Ohio

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able to satisfy the demand for 'middle-of-the-barrel' fractions, primarily kerosine, heating oil and diesel oil.

"Our engineers are being required, for plants in United Kingdom, France and Belgium, to stress the production of the minimum of gasoline and maximum of 400-650° F. stock.

"Already some European refiners slant their plans toward catalytic cracking and catalytic reforming as the most efficient ways to meet the anticipated eventual call for quantity production for high quality gasoline."

Kellogg reported that it is currently modernizing one of France's major refineries located at Martigues as well as plants at L'Avera, Gonfreville and Dunkirk.

Kellogg sees in the world survey a major challenge to the engineering-contractor who will have to "make recommendations in accord with changing world conditions" and will have to build flexibility into refineries so that they may "operate advantageously under a wide variety of crude supply and market conditions."

Hi-Way Refineries Plans Refinery for Saskatchewan

Hi-Way Refineries, Ltd., has let a contract for a new oil refinery at Saskatoon, Saskatchewan, the plant to consist of a 2000-barrel per day crude topping unit and a 500-barrel per day Dubbs licensed thermal cracking unit, together with all the necessary auxiliaries for a complete modern refinery.

Contract for the design, engineering and construction has been awarded to The Refinery Engineering Company, Tulsa.

Italian Refinery Planned

California Texas Oil Company, Ltd. and Petrolea Company are cooperating in the building of a refinery at Trecate, Italy. To operate on Middle East crude oil, the plant will have a capacity of 10,000 to 20,000 barrels daily. Crude storage equal to about a month's throughput is included in the construction project.

Petrolea will also expand its storage at Vado Ligure, Italy, to 425,000 barrels.

Belgian Plant To Be Built

Anglo-Iranian Oil Company, Ltd. and Cie. Financiere Belge des Petroles, generally known as Petrofiña, have formed a joint company, Societe Belge des Petroles, for the construction of a refinery at Antwerp, Belgium.

To have a daily capacity of 30,000 barrels, the refinery will get under way in 1949 with completion due some time during 1951 or 1952.

Australia to Get Refinery

Shell Oil Company is to build a complete oil refinery in Victoria, Australia. To cost approximately $6 million, it will take two years to build. Imported crude oil will come from sterling areas, according to E. Avery, the company's general manager in Australia.

Two Executives Promoted By Standard Development

Gohr

Reeves

E. Duer Reeves, vice president and director since 1947, has been named executive vice president of Standard Oil Development Company, and Edwin J. Gohr, assistant manager of the research and development department since 1945, will become a vice president and director.

D. R. Johnson New Head Continental Manufacturing

D. R. Johnson has been appointed manager of the manufacturing department of Continental Oil Company with supervision over the company's eight refineries. Formerly manager of the southern region of the manufacturing department, Johnson will be succeeded by L. W. Vickery, superintendent of Continental's Ponca City refinery.

Johnson

Charles D. Hull, named superintendent of the Ponca City plant, will be succeeded as assistant to the president by C. B. Round, former analyst in the company's coordinating and planning department.

Bureau of Mines Estimates Reduction In Oil Demands

Estimating the January market demand for domestic crude will be 5,480,000 barrels daily, the Bureau of Mines has noted that this is a decrease of 100,000 barrels daily over previous estimates. Total gasoline demand is given as 70 million barrels daily, total crude runs to stills as 5,620,000 barrels daily and gasoline from crude of 40 percent.

Magnolia's Expansion Work To Increase Gas Recovery

The expansion program of Magnolia Petroleum Company at its Sabine Valley gasoline plant at Kilgore, Texas, is attempting to recover more liquid products from the gas, especially propane. It is estimated that the propane recovery from the wet gas will be increased from approximately 40 percent to 70 percent. This, along with other improved efficiencies, will account for the recovery of approximately 20,000 gallons per day of additional liquid products.

Additional refrigeration capacity is also being installed which, in conjunction with other changes, will leave the resultant processing facilities essentially that of a refrigeration-compression plant. Among other modernization work being carried on, an engine generator plant is being constructed which will allow the auxiliary facilities to be electrically driven.

Effort has been made to minimize the amount of fuel gas used in the plant and a program is underway to minimize the consumption and misuse of fuel gas being supplied the leases connected to the plant.

Delta Engineering Corporation, Houston, are contractors for the construction project. Z. P. Armstrong, Magnolia district superintendent at Kilgore, is supervising the job.

Anglo-Iranian Increases Llandarcy Refining Output

Production at the Llandarcy refinery of Anglo-Iranian Oil Company, subsidiary of National Refineries Ltd., has risen from a daily capacity of 6731 barrels for the period of July, 1946 to June, 1947 to 10,484 barrels daily for the period of July, 1947 to June, 1948. Total production for the 1946-47 period was 2,457,000 barrels and 3,813,600 barrels for the 1947-48 period.

At present the refinery is being expanded to a daily capacity of 19,178 barrels or 7 million barrels of crude oil annually. Estimated cost of the scheme is $38 million.

Brazilian Plant Underway; Three Refineries Planned

Rafinaria Nacional de Petroleo, S. A. together with the government Conselho Nacional de Petroleo will start construction on a refinery at Bahia, Brazil, early in 1949. Engineering work and procurement of materials is nearly complete and some material has been shipped. The plant, which has a 2500 barrel daily capacity, will be a combination unit with thermal cracking facilities. The M. W. Kellogg Company is contractor.

The Brazilian government is also planning to construct refineries in the federal district of Rio de Janeiro, at Belem and Sao Paulo. All will use imported crude oil. Equipment may come from France and Czechoslovakia, using accumulated currency balances.

English Company to Build New Oil Dock at Eastham

The Manchester Ship Canal Company has authorized the promotion of a Parliament bill which seeks power to build a new oil dock at Eastham, England. Costing about $16 million, the dock will be 800 feet long and 100 feet wide and will accommodate tankers up to 30,000 tons. Construction of the dock is expected to take three years.

Crude petroleum cargoes for the refinery being built at Stanlow, England, by Shell Oil Company, will be discharged at the proposed dock.

Cities Service to Build Natural Gasoline Plant

Cities Service Oil Company is planning a natural gasoline plant to process casinghead gas produced in the Chico field of Wise County, Texas. The plant will be located in the field.

Present plans call for an eventual processing capacity of 22 million cubic feet of gas daily and the installation of

THE MONTH . . .

five 600-hp. units. Completion of the first step in the program is scheduled for late this year.

O. V. Tracy Manages Esso Chemical Products Section

Osgood V. Tracy has been named manager of the chemical products department of Esso Standard Oil Company. He has been assistant manager of the department.

Tracy

Closely associated with the development of synthetic rubbers, alcohols and other chemical products from petroleum since he joined the company in 1930, Tracy has previously served as division head of the Standard Oil Development Company, central technical organization of Standard Oil Company (New Jersey) affiliates, and as manufacturing coordinator of chemical products for Esso Standard. He will continue as a director of Enjay Company, Inc., chemical products marketing affiliate of Esso.

A graduate of the United States Naval Academy in 1924, he is a member of the American Chemical Society and the Cornell Club of New York.

Indiana Standard Group Wins 34 Safety Awards

For achieving the record of 62,535,165 man-hours without an accident, employes of Standard Oil Company (Indiana) and its subsidiaries received 34 of 59 safety certificates awarded in the oil industry by the American Petroleum Institute in 1948. In 1947 the Standard group won 24 of 34 awards. Each certificate recognizes success in preventing accidents in a different branch of operations or location for one million or more man-hours of work without loss of time or disabling injury.

Standard received 16 certificates in the refining department and 19 in the marketing department. Stanolind Oil and Gas Company received a certificate in the production department, and Stanolind Pipe Line Company received the only award in the pipe-line department. Root Petroleum Company won a certificate in the miscellaneous department.

Socony-Vacuum Opens Five-Week Training Course

Socony-Vacuum Oil Company, Inc., opened a five weeks training course January 17 on various aspects of industrial relations procedure and policies. Most sessions will be held in the company's New York headquarters, but several field trips have been arranged.

Discussion leaders include W. H. Montgomery, manager of industrial relations, and other members of Socony's industrial relations department.

H. F. Sinclair Resigns; P. C. Spencer Takes Place

H. F. Sinclair last month resigned as president of Sinclair Oil Corporation and was elected chairman of the board of directors. Succeeding him as president is P. C. Spencer, president of Sinclair Refining Company and formerly executive vice president of the parent company.

Spencer

Founder and chief executive of Sinclair Oil Corporation for 33 years, Sinclair asked to be relieved of active direction of operations now that the corporation's $150 million expansion program is nearly completed.

Joining Producers and Refiners Corporation in 1922, Spencer was made general counsel in 1927. When Sinclair acquired Prairie Oil and Gas Company, of which Producers and Refiners was a subsidiary, he became active in the legal department of the Sinclair organization. In 1946 he became general counsel and in 1947 he was named president of Sinclair Refining.

Oil Industry Is Leader In Scientific Research

The leader in scientific industrial research since World War I, the oil industry has spent for petroleum research more than 25 percent of the funds spent by all private industry for research, Richard J. Lund, head of the engineering division of Battelle Memorial Institute, told the Cleveland Petroleum Club recently.

Citing figures from Standard Oil Development Company, Lund said that the company has earned more than $15 on every dollar spent in research. For every research dollar it has saved $3.72 in royalty payments, $8.62 in improvements on established processes or old products and gained $2.07 in new profits from new products. Oil research also has been responsible for new developments in the fields of geology and geophysics.

Government May Conduct A Petroleum Industry Census

The "advisability and desirability" of the government conducting a petroleum industry census in 1950 to cover 1949 will be investigated by a National Petroleum Council committee headed by H. S. M. Burns, Shell Oil Company.

Other members of the committee are Hines H. Baker, Humble Oil & Refining Company; Max W. Ball, Washington, D.C.; William R. Boyd, Jr., American Petroleum Institute; Bruce K. Brown, Military Petroleum Advisory Board; Russell B. Brown, Independent Petroleum Association of America; E. Degolyer; Fayette B. Dow, National Petroleum Association; R. G. Follis, Standard Oil Company of California; Jake L. Hamon, Cox and Hamon; D. A. Hulcy, Lone Star Gas Company; B. Brewster Jennings, Socony-Vacuum Oil Company, Inc.; Frank H. Lerch, Jr., Consolidated Natural Gas Company; L. F. McCollum, Continental Oil Company; J. S. Morris, American Association of Oilwell Drilling Contractors; Joseph E. Pogue, Chase National Bank; Frank M. Porter, Mid-Continent Oil and Gas Association; W. F. Sehmann, National Stripper Well Association; and C. R. Williams, Natural Gasoline Association of America.

Brown Instrument Makes New Division In Courses

Industrial instrument maintenance and repair courses which have been conducted for the past 15 years by Brown Instruments Division of Minneapolis-Honeywell Regulator Company will be divided during the first six months this year into four classes of five weeks each, continuing through to June 17.

The longer course for company, to start February 21, will be sub-divided into specific classes for instruction in millivoltmeters, mechanical pyrometers, continuous balance electronic potentiometers, electrically operated automatic control, flow meters, thermometers, pressure gauges and hygrometers, air-operated control, Moist-o-Graphs, tachometers, resistance thermometers, CO_2 and analygraph.

GM Supplies Test Engines

General Motors Research Laboratories will supply high compression test engines to oil companies for use of petroleum chemists in studying future automative fuels. Essentially the engine is a 7.25-to-1 Oldsmobile "Rocket" power plant outfitted with three sets of cylinder heads and other parts for operation at 8, 10 and 12-to-1 compression ratios. In addition to the test engines, the oil companies are ordering models of the 98-series Oldsmobile cars into which the research engines can be fitted for road testing.

NACE To Give Technical Papers In Eleven Symposia

Technical papers scheduled to be delivered at the 1949 conference of the National Association of Corrosion Engineers to be held April 11-14 in Cincinnati, Ohio, will be given at 11 symposia. The schedule includes:

April 11, symposium on corrosion principles, H. H. Uhlig, Massachusetts Institute of Technology, "Why Metals Corrode," and Hugh J. McDonald, Loyola University, "The High Temperature Corrosion of Metals."

April 12, chemical industry symposium, Glenn A. March, The Pure Oil Company, "The Pulse Polarizer in Corrosion Technology." Electrical and communications industries symposium, T. J. Maitland, American Telephone and Telegraph Company, "Corrosion Testing of Buried Cables."

April 13, cathodic protection symposium, "Engineering Aspects of Cathodic Protection as Applied to Pipe Lines," by E. P. Doremus, G. L. Doremus and M. E. Parker, Cathodic Protection Service; T. P. May, The International Nickel Company, "Cathodic Protection Distribution in Some Zinc Steel Systems," and George S. Gordon, Northwestern University, "The Corrosion Products on Zinc Anodes Used Underground." General industry symposium, E. L. Walters and R. G. Larsen, Shell Development Company, "Field and Laboratory Evaluation of Petroleum-Base Rust-Preventives" and W. A. Luce and M. G. Fontana, The Ohio State University, "Erosion-Corrosion of Metals and Alloys." Transportation industry symposium, "Electrolytic Corrosion of Steel in Concrete," by G. M. Magee, Association of American Railroads.

April 14, protective coatings symposium, G. H. McIntyre, Ferro Enamel Coporation, "Porcelain Enamel as a Corrosion Resistant Coating"; S. C. Frye, Bethlehem Steel Company, "Shot Coat Primers for Steel"; W. W. Cranmer, Industrial Testing Laboratory, Philadelphia Naval Shipyard, "Writing Specifications for Organic Metal Protective Coatings"; and William T. Deacon, Solvents and Plastics

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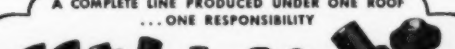

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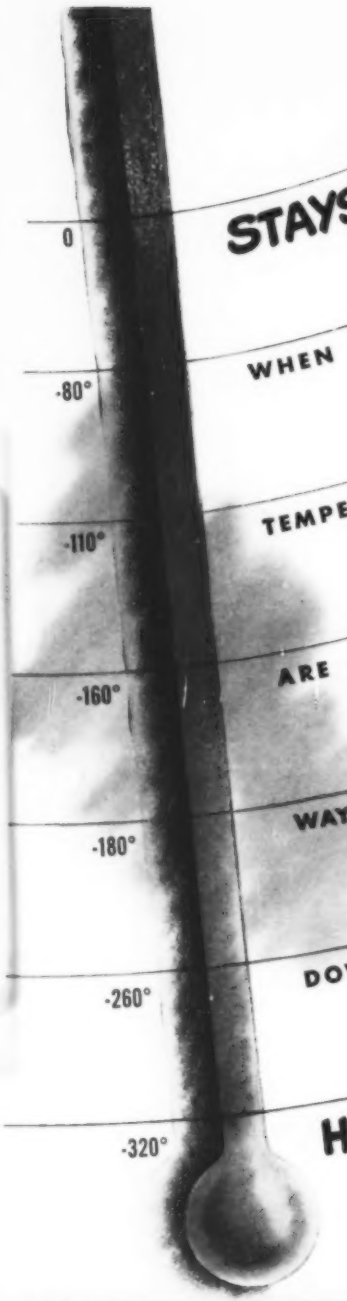

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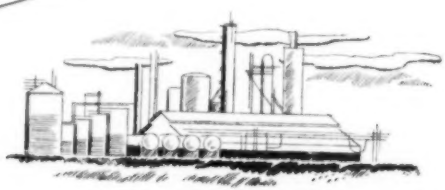
There's a wealth of technical help for you on all types of process equipment at Alcoa's research center. Consult us about data, designs, tests and pilot equipment. ALUMINUM COMPANY OF AMERICA, 1951 Gulf Building, Pittsburgh 19, Pa.



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THE MONTH...

Company, "Cationic Chemical Pretreatment of Metal Surfaces."

Oil industry symposium—R. S. Treseder, Shell Development Company, will discuss "Corrosion in Petroleum Processes Employing Aluminum Chloride"; A. B. Culbertson, Shell Oil Company, "Anti-Corrosive Lubricants for Internal Combustion Engines"; and I. B. Tietze, Phillips Petroleum Company, "Correlation Between Corrosion Survey Results and Actual Conditions."

Salt water corrosion symposium—"Corrosion Resistance of Aluminum and Aluminum Alloys in Sea Water," William C. Stewart, U. S. Naval Engineering Experiment Station; "Corrosion of Steel Pipe by Chlorinated Sea Water at Various Velocities," V. B. Volkening, The Dow Chemical Company, Freeport, Texas; "Corrosion of Steel Piling in Sea Water," H. A. Humble, The Dow Chemical Company, Midling, Mich.; and "Deterioration of Steel Piling at Palm Beach," by Beach Erosion Board.

Gas industry symposium—A. W. Peabody and C. L. Woody, Ebasco Services, Inc., "Cathodic Protection of Gas Distribution Systems"; O. C. Mudd, Shell Pipe Line Corporation, "Preparation of Reconditioned Pipe Surfaces for Effective Application of Bituminous Coatings"; H. J. Findley, Eaton Manufacturing Company, "The Use of the Thermo Generator for Cathodic Protection"; and C. Kenneth Eilerts, Bureau of Mines, "Field Tests of Sodium Chromates and Alkalies for Controlling Corrosion in Gas-Condensate Wells."

Indiana Standard Promotes Two At Sugar Creek Plant

Boehmer

Cash

H. R. Boehmer, general superintendent of the Sugar Creek, Mo., refinery of Standard Oil Company (Indiana), has been promoted to manager at Sugar Creek to succeed the late R. E. Beard. R. M. Cash, superintendent of the process division at Sugar Creek, has succeeded Boehmer as general superintendent.

Joining Standard in 1915 at the Whiting, Ind., refinery Boehmer was transferred to Sugar Creek as a chemist in 1916. He became superintendent in 1920 and general superintendent in 1946. He is an alumnus of University of Wisconsin.

Cash became associated with the company in 1926 as a laboratory assistant at Sugar Creek. After advancing to foreman of the asphalt department in 1932 and general foreman in 1945, he was appointed superintendent of the process division in 1946. He is an alumnus of Iowa State College.

Du Pont Gives Grants for Chemical Research Projects

E. I. Du Pont de Nemours & Company is instituting a program of grants-in-aid to ten universities for the 1949-50 academic year for unrestricted use in the field of fundamental chemical research. The program, which at the start will be on a trial basis, has the aim of raising the amount of such research being done in this country above present levels, with a view to "stock-piling basic knowledge."

The ten universities to which grants-in-aid of $10,000 each are being offered are California Institute of Technology, Cornell University, Harvard University, Massachusetts Institute of Technology, Ohio State University, Princeton University, Yale University, University of Illinois, University of Minnesota and University of Wisconsin.

The grants are being awarded for the academic year of 1949-50, but it is the company's hope, should the program work out satisfactorily, to continue each of them for a period of five years. The universities themselves will select the research projects in which the grants will be employed.

Gasoline Octane Ratings Up Slightly From 1947

Regular and premium-priced gasolines sold in American service stations, during the summer of 1948 were of slightly higher quality with respect to octane ratings than those sold during the two preceding summers, reflecting a continued upward trend in the quality of post-war gasolines, according to a semi-annual survey of motor fuels released by the Bureau of Mines.

The report, based on analyses of 2997 samples of gasoline from 17 marketing areas throughout the nation, shows that the octane ratings of regular gasolines sold in the summer of 1948 averaged 75.2 compared with 75.1 for the summer of 1947 and with 74.4 during 1946. Similarly, the ratings of premium-priced gasolines last summer averaged 79.5 as compared with 79.2 during the previous summer and with 78.3 and 74.9 respectively, for the two preceding summers.

Including service station gasolines of 115 major and minor companies, the survey of last summer was the second made by the Bureau in cooperation with the American Petroleum Institute.

A copy of Report of Investigations 4444, "National Motor-Gasoline Survey, Summer 1948," may be obtained by writing to the Publications Distribution Section of the Bureau of Mines, 4800 Forbes St., Pittsburgh 13.

Continental Makes Changes In Gasoline-Gas Division

Continental Oil Company has made changes in its natural gasoline and gas divisions as follows:

J. R. Bailey to be assistant manager of the division. Graduating from the Colorado School of Mines with a degree in petroleum engineering, he joined Continental in 1940, becoming superintendent of development in 1947.

F. B. Willson to be superintendent of development succeeding Bailey. Prior to this appointment he had been assistant to the manager of the division since 1946. He joined the company in 1936. After attending the University of Michigan, Willson received his bachelor of science degree in business administration and economics at the University of Colorado in 1924.

J. M. Cook to be chief clerk of the division. He studied mechanical engineering at the University of Arkansas and at Arkansas Polytechnical College.

Lynn Strawn Appointed Jefferson Plant Manager

Strawn

Lynn R. Strawn, formerly of The Texas Company at Port Arthur, Texas, has been appointed manager of the Port Neches, Texas, plant of Jefferson Chemical Company, Inc. He succeeds A. A. Triska, who has returned to New York to become assistant to the manager of the production department.

Prior to accepting the new position with Jefferson, Strawn was in charge of process engineering activities in all phases of light oil and lubricating oil manufacture and gas processing at the Port Arthur plant.

He holds a bachelor of science degree in chemical engineering from Denver University and a master of science degree from Columbia University.

General Petroleum Issues Retirements, Advancements

Retirements and advancements, effective January 1, 1949, have been announced by General Petroleum Corporation.

V. F. Grace, manager of the engineering department, and E. H. Vanderbilt, maintenance foreman of the gas department, have retired.

C. G. Cortelyou has become project engineer, and C. M. Reading has become manager of the engineering department. J. J. Tobin will be chief estimator and A. B. Westlake job engineer.

In the manufacturing department H. R. Alfson has been promoted to gas engineer and C. W. Walker has become maintenance foreman, gas department.

Oronite Names J. T. Deane

J. T. Deane has been elected vice president of Oronite Chemical Company. He comes to Oronite from California Oil Company's Oak Point, La., plant. He was a vice president of that company, and manager in charge of manufacturing of lubricating oil additives.

W. Wallace Kemp Dies

W. Wallace Kemp, president of C. M. Kemp Manufacturing Company, Baltimore, Md., died recently at his home in Baltimore. He had been president and chairman of the board of directors since 1912, succeeding his father, Clarence M. Kemp, founder of the company. The Kemp automatic gas system for the efficient combustion of fuel won for Kemp in 1920 the Edward Longstreth medal of merit from the Franklin Institute.

Leo W. Knapp Dies

Leo W. Knapp, sales engineer for Oliver United Filters, Inc., died December 18, 1948, from injuries suffered in an automobile accident in Pennsylvania. Born in Yatesville, Pa., on May 24, 1890, he was a graduate of the Philadelphia College of Pharmacy, now a part of the University of Pennsylvania. He joined Oliver 12 years ago.

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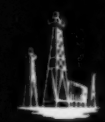
4 XVG-150 HP

8 XVG-300 HP

6 XVG-225 HP

6 JVG-150 HP



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These abstracts are selected from the current literature of science and technology, not including trade journals easily available. Photostatic copies of original articles will be supplied at cost by The Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, also will be prepared and furnished by arrangement with the Laboratories.

FUNDAMENTAL PHYSICAL AND CHEMICAL DATA

Applicability of the Eykman Equation. R. R. DREISBACH, *Ind. Eng. Chem.* **40** (1948), pp. 2269-71.

In 1895 J. F. Eykman developed an empirical formula relating the refractive index, the density and a constant C. When rearranged, it was obvious that this equation is the Newton refraction and varies linearly as the first power of n. On the other hand, the rearranged Lorenz-Lorentz expression indicates the Newton refraction varies linearly as the second power of n. The author found that the Eykman equation is correct. If two densities and one refractive index at the same temperature as one of the densities are known for a compound, the refractive index can be determined at the temperature of the second density. The Eykman equation provides a method for checking the accuracy both of densities and of refractive indices.

Vapor Pressures of Trimethylbenzenes in the Low Pressure Region. E. R. HOPKE AND G. W. SEARS, *Jour. Am. Chem. Soc.* **70** (1948), pp. 3801-3.

Vapor pressures of the isomeric trimethylbenzenes have been reported in the region 10-750 mm. The present paper reports the vapor pressures of these compounds in the region 0.01-1.0 mm. Measurements were made with a Rodebush manometer. The data were found to fit the equation

$$\log_{10} P = -(A/T) + B$$

Comparison of the data by an extrapolation method with data of previous workers in a higher pressure range show that agreement is satisfactory.

Vapor-Liquid Equilibria of the System Butadiene-Styrene. RICHARD W. WILHELM AND DONALD W. COLLIER, *Ind. Eng. Chem.* **40** (1948), pp. 2350-3.

Vapor-liquid equilibria of the system butadiene-styrene cannot be estimated simply by the use of Raoult's law because there is a significant heat of mixing of the liquids as well as a deviation of vapors from the perfect gas law. Direct measurements of the equilibria are subject to error because of a tendency to polymerize, particularly above 25° C. Vapor-liquid equilibrium measurements for the system butadiene-styrene were made at 0° C. in butadiene-rich and styrene-rich solutions. The Hildebrand-Scatchard equation correcting for deviations in the liquid phase from Raoult's law as well as from the gas laws was found to fit the data satisfactorily. This equation was used to compute equilibria from —15 to 80° C. for the full range of compositions. Partial pressures, partial heats of mixing and x-y relationships are given. The data are presented in considerable detail in tabular and graphical form.

Mass Spectra of Some Organic Compounds. R. H. ROBERTS AND S. E. J. JOHNSEN, *Analytical Chem.* **20** (1948), pp. 1225-1231.

The original paper on Mass Spectra of Some Organic Compounds (published in *Anal. Chem.* **20** (1948), p. 690) was found to contain many serious errors in the tabulated data, so many in fact that the customary errata sheet would serve no useful purpose. It was therefore decided to reprint all of the revised tables, though some originally contained no errors.

Knocking Characteristics of Hydrocarbons. WHEELER G. LOVELL, *Ind. Eng. Chem.* **40** (1948), pp. 2388-2438.

The author states that it is the primary purpose of this paper to gather together all the data that pertain to the knocking behavior in engines of hydrocarbons of definite structure. The data presented were obtained from three sources, first the literature, second and most extensive is the publications of API Research Project 45, and third the publications of the National Advisory Committee for Aeronautics. The data have been critically reviewed and tabulated in a form from which all of the information on any compound can readily be obtained. More than 325 hydrocarbons are covered. In order to increase the utility of this mass of information and make it more coherent, the more obvious correlations have been developed. Relationships are shown between different methods of engine testing, between structure and knock for various chemical classes of compounds, between the knock behavior of hydrocarbons straight and in solution, and between the nature of the hydrocarbon and the extent to which tetraethyllead is effective in changing the antiknock value. A bibliography of 42 references is included and the data are presented in 25 pages of tables.

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Molybdenum oxide tetrafluoride
1-Butyne-3-ol
5-Hydroxy-1,4-naphthaquinone
Melissyl alcohol
Carbonyl sulfide
1,3-Diazine
1,4-Diazine
1,2,4-Triazine
1,3,5-Triazine
1,2,3,5-Tetrazine
1,2,4,5-Tetrazine
Pentazine

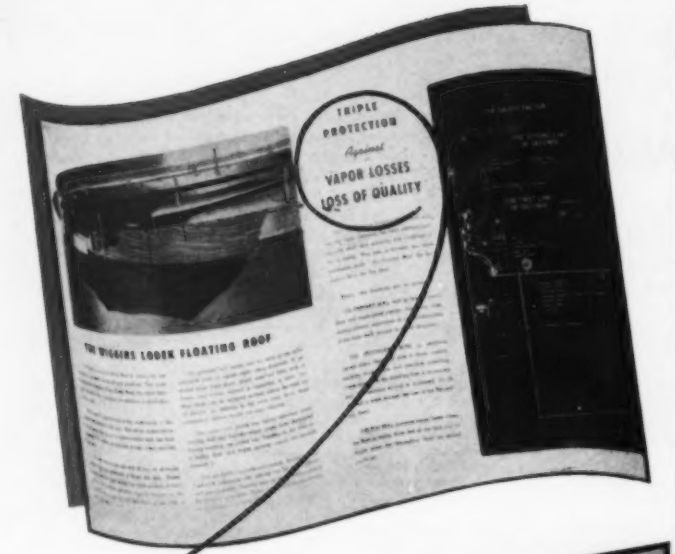
CHEMICAL COMPOSITION AND REACTIONS

Reaction of Paraffin Hydrocarbons with Phosphorus Trichloride and Oxygen to Produce Alkanephosphonyl Chlorides. J. O. CLAYTON AND W. L. JENSEN, *Jour. Am. Chem. Soc.* **70** (1948), pp 3880-3882.

In an investigation of organic phosphorous compounds a new synthetic method was discovered for producing phosphonyl chlorides from aliphatic hydrocarbons. On mixing open chain or cyclic aliphatic hydrocarbons with phosphorus trichloride, and bubbling the mixtures with oxygen, alkane or cycloalkanephosphonyl chlorides were produced. Reaction of various hydrocarbons or mixtures of hydrocarbons were studied including white oil, n-heptane, 3-methylpentane, cyclohexane, propane, toluene and higher benzene homologs. Benzene itself did not react. Olefins reacted readily but the reaction products contain chlorine, indicating a probable addition of phosphorous trichloride across the double bond.

Effect of Hydrogen on Action of Aluminum Chloride on Alkanes. V. N. IPATIEFF AND LOUIS SCHMERLING, *Ind. Eng. Chem.* **40** (1948), pp. 2354-60.

Much work has been done on the action of aluminum chloride or aluminum bromide on the hydrocarbons. The re-



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sults of this work may be summarized by stating that, in general, the primary reactions are isomerization and autodestructive alkylation. The latter reaction is a combination of cracking and alkylation and results in the formation of isoparaffins of lower and higher boiling point than the original paraffin. The authors found that molecular hydrogen at superatmospheric pressure has a marked effect on the action of aluminum chloride on paraffins. When *n*-pentane is heated with pure aluminum chloride at 125° C. in the presence of hydrogen, no reaction occurs; if nitrogen is used instead of hydrogen, autodestructive alkylation takes place, resulting in the formation of butanes, hexanes and higher boiling paraffins, and in the conversion of the catalyst to a viscous red liquid. If, on the other hand, the reaction under hydrogen pressure is conducted in the presence of a promoter such as hydrogen chloride or water, isomerization to isopentane occurs in excellent yield with virtually no side reaction and the catalyst remains crystalline. Hydrogen does not prevent the autodestructive alkylation of heptane and higher molecular weight alkanes in the presence of pure aluminum chloride. However, if hydrogen chloride is added, destructive hydrogenation occurs and molecular hydrogen is consumed. This reaction has the advantage over autodestructive alkylation in that it results in a higher yield of isobutane and a smaller yield of catalyst complex. Also, the catalyst complex formed in the presence of hydrogen is more active than that formed in the absence of hydrogen. This results in longer catalyst life. Destructive hydrogenation of a Fischer-Tropsch naphtha is described and the effect of changes in certain variables is discussed. The data are presented in considerable detail in tabular and graphical form and a bibliography of 17 references is included.

Kinetics of the Polymerization of Propylene with Aluminum Bromide-Hydrogen Bromide Catalyst. C. M. FONTANA AND G. A. KIDDER, *Jour. Am. Chem. Soc.* **70** (1948), pp. 3745-51.

The kinetics of the polymerization of propylene by means of aluminum bromide in the presence of hydrogen bromide promoter were studied. Approximate values of a rate constant, an equilibrium constant and the corresponding activation and heat energies were determined. The heat of polymerization of propylene was found to be approximately 16.5 kcal. per mole. A reaction mechanism that will account for the data as observed is proposed.

Deuterium Exchange, Isomerization and Hydrogenation of *n*-Butenes. Mass Spectrometric and Infra-Red Study of Rates of Deuterium Exchange, Isomerization and Hydrogenation of the *n*-Butenes. V. H. DIBELER AND T. I. TAYLOR, Columbia University, *J. Chem. Phys.* **16** (1948), pp. 1008-9.

Reactions were effected with equimolar quantities of hydrogen and *n*-butene, and catalyzed by Nickel. Rates of formation of deuterobutenes and of butane were observed by mass spectrometric analysis, and the rate of isomerization was followed by the use of infra-red adsorption at 925 cm^{-1}. Initially the reaction between deuterium and 1-butene is 93-130° C., the rate of isomerization is only slightly greater than the rate of exchange. In progress of the reaction, deuterium is diluted with protium, and the apparent

exchange rate decreases, while the isomerization rate increases. Initially, the rate constant for deuterium induced isomerization was about 20 times that of deuterium addition, while the rate of protium-induced isomerization was approximately twice that of protium addition. One may conclude that the addition and the isomerization-exchange mechanisms are different.

Alkylation of Thiophene with Olefins. PHILIP D. CAESAR, *Jour. Am. Chem. Soc.* 70 (1948), pp. 3623-5.

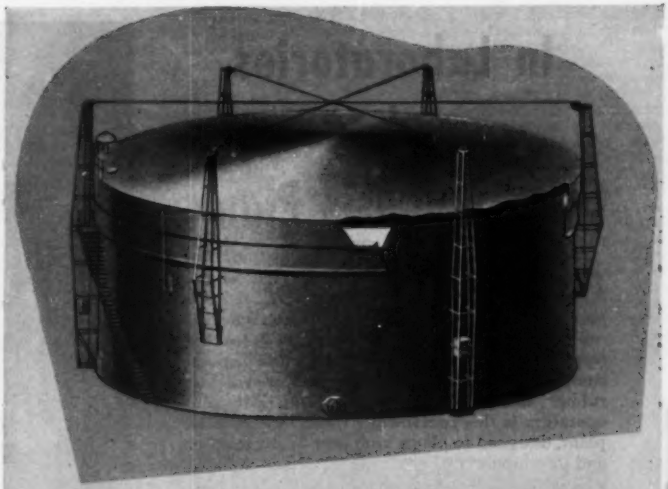
Sulfuric acid, dihydroxyfluoboric acid, aluminum chloride, and boron trifluoride complexes with water or organic oxygen-containing compounds promote the alkylation of thiophene with isobutylene, pentenes, diisobutylene, 1-actene and 1-hexadecene. Several new mono- and dialkylthiophenes were made. Yields of 2-*t*-alkylthiophenes of 80 percent of the theoretical were obtained by catalyzing the alkylation of equimolar quantities of thiophene and relatively reactive olefins with 70-80 percent sulfuric acid or with dihydroxyfluoboric acid at 30-85° C. High yields of 2, 5-di-*t*-alkylthiophenes were obtained by using boron trifluoride-diethyl ether complex as catalyst. Combined yields of mono- and dialkylthiophenes of 65-90 percent of theoretical were obtained using concentrated sulfuric acid or boron trifluoride-water at 75-150° C. to promote alkylation with less reactive straight-chain olefins.

Cracking of Fischer-Tropsch Waxes. Production of Olefins by the Cracking of Fischer-Tropsch Waxes and Their Conversion into Lubricating Oils. G. H DAZELEY AND C. C. HALL, Fuel Research Station, *Fuel* (1948), pp. 50-5, May-June.

The paper describes the thermal cracking of two waxes produced in the Fischer-Tropsch process and also the production of lubricating oils from the resulting olefins. The waxes made at atmospheric pressure and at ten atmospheric pressure by synthesis from hydrogen and carbon monoxide in the presence of cobalt catalyst were subjected to non-catalytic vapor-phase cracking at temperatures of 500-640° C. Yields, composition and properties of the products were determined and compared with those from the cracking of diesel oil. The total yield of cracked products was less than for diesel oil, but the yield of liquid products was higher. At atmospheric pressure cracking -olefins of fairly high purity were recovered from the cracking products. The principal hydrocarbon produced was ethylene. Polymerization of the olefins with aluminum chloride gives greater yields of lubricating oil of high viscosity index than are obtained from products of cracking of diesel oil. This is occasioned by the greater production of long-chain olefins from the waxes. All of the oils had B.A.M. oxidation numbers above 2.0.

Some Mechanism Studies on the Fischer-Tropsch Synthesis Using C." J. T. KUMMER, T. W. DEWITT AND P. H. EMMETT, *Jour. Am. Chem. Soc.* 70 (1948), pp. 3632-43.

Fischer-Tropsch synthesis experiments using C^{14} as a "tracer" show that the greater part of the product of synthesis is that formed by the reduction of carbide. Only about 10 percent of the hydrocarbon product is formed through the carbide for iron catalysts at or below 260° C. and for cobalt at 200° C. The



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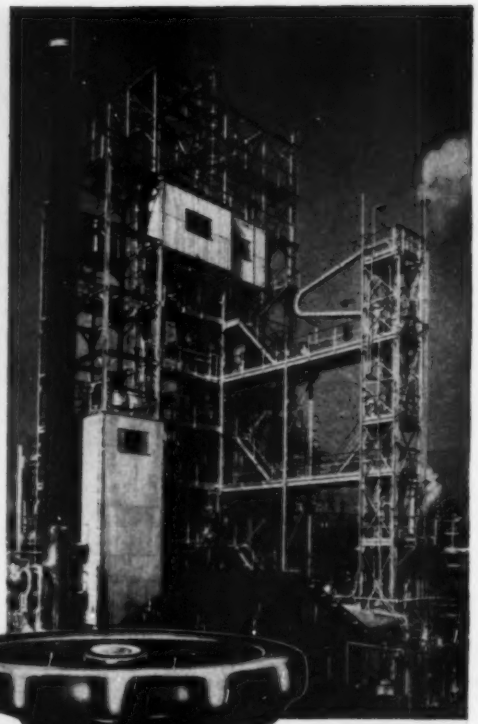

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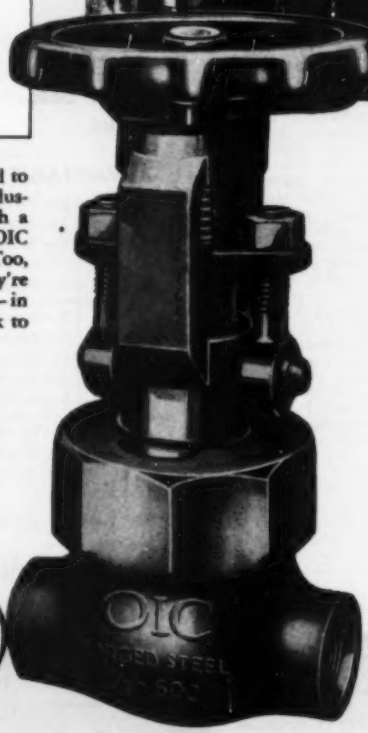

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percent formed through the adsorbed phase is not critically dependent on the hydrogen:carbon monoxide ratio in the range 1:1 to 3:1, on the total pressure of the synthesis, within the range 150 to 800 mm.; or on the percent Fe_3C initially present in the range 4 to 100 percent. The exchange of carbon in the gases, methane, butane, butene-1, and acetylene, with a carbide surface at 250° C., was found to be low. No completely satisfactory picture of the mechanism of carbiding was formulated.

Isomerization of *n*-Pentane. Effect of Various Additives. JULIAN M. MAVITY, HERMAN PINES, RICHARD C. WACKHER AND JOHN A. BROOKS, *Ind. Eng. Chem.* **40** (1948), pp. 2374-9.

The investigation reported was concerned with the effect of various organic additives in controlling side reactions in the isomerization of *n*-pentane to isopentane. Normally the isomerization of *n*-pentane to isopentane in the presence of aluminum-chloride-hydrogen chloride catalyst is accompanied by considerable cleavage and disproportionation. Among the additives found to be most effective for repressing the side reactions were certain naphthenic and aromatic hydrocarbons. Straight run C_6 fractions containing small or moderate concentrations of benzene or C_6 naththenes also proved satisfactory. Some aromatic compounds, such as chlorobenzene and diphenyl ether, showed similar properties. The concentration of a given additive must be controlled carefully to obtain the optimum effect for an excess was found to repress isomerization as well as the side reactions. Thus while 5 to 10 volume percent of cyclohexane gave good results, the optimum concentration of benzene was 0.25 to 0.5 volume percent. In the course of the work both batch tests and continuous runs of the aluminum chloride pickup type were made. In the latter type of procedure the additive has the additional function of repressing sludge formation in the aluminum chloride supply zone. The mechanism of the reactions is briefly discussed. The data secured in the course of the work are presented in tabular and graphical form and a bibliography of 18 references is included.

MANUFACTURE: PROCESSES AND PLANT

Phase Relations for Petroleum Fractions. WAYNE C. EDMISTER AND D. H. POLLOCK, *Chem. Eng. Progress* **44** (1948), pp. 905-26.

The paper presents the results of an experimental investigation and correlation studies that were made to develop an improved empirical method for predicting equilibrium flash-vaporization conditions. In order to provide experimental data on which to base the development of such a method, equilibrium flash-vaporization runs were made on 27 typical refinery stocks. Twenty-one of these runs were made at atmospheric pressure only, while the remaining six were were conducted at pressures up to 200 pounds psig. ASTM distillations were obtained on the equilibrium vapor and liquid from the runs on nine of these stocks. In addition to these flash-vaporization data, true-boiling-point distillation data were procured for six of these stocks and also for six additional stocks. Based on these data, plus all the data available in the literature, an improved empirical method for predicting the equilibrium flash-vaporization curves of petroleum fractions at various pressures was developed. This method comprises: a) a three-way correlation relating ASTM, true boiling point and atmospheric-pressure equilibrium flash vaporization distillation curves, b) a critical point correlation, and c) a correlation for effect of pressure on the equilibrium flash vaporization curve. An example of the application of the method in the design of distillation equipment is presented.

Butadiene from Ethanol. Utilization of By-Product Ethyl Acetate. E. E. STAHLY, H. E. JONES AND B. B. CORSON, *Ind. Eng. Chem.* **40** (1948), pp. 2301-3.

The Carbide and Carbon Chemicals Corporation's process for manufacturing butadiene from ethanol comprises passing a mixture of approximately 62.7 mole percent ethanol, 22.8 mole percent acetaldehyde, and 14.5 mole percent water over a tantalum pentoxide (2 percent)-silica (98 percent) catalyst. Various by-products were formed in the process, some of which were recovered as marketable chemicals, others were recycled with recovered ethanol and acetaldehyde, but most of them, including a major part of the ethyl acetate, were burned as fuel. In the investigation reported it was shown that butadiene results from the reaction of ethyl acetate with acetaldehyde in the presence of a tantala-silica catalyst at 325 to 350° C. Therefore, it is possible to increase the efficiency of the ethanol process for the manufacture

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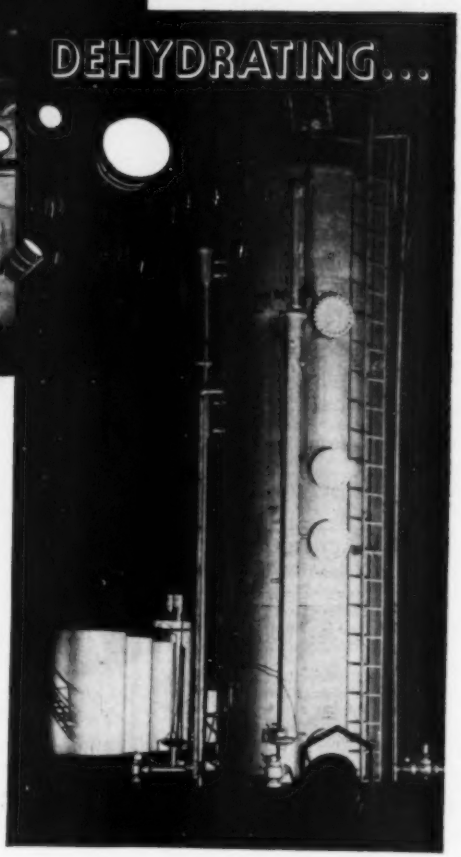

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of butadiene by recycling the by-product ethyl acetate. The first step in the utilization of ethyl acetate is the formation of ethanol by hydrolysis. The steady-state concentration, at which the amount of ethyl acetate formed per pass equaled the amount consumed, was determined for commercial operating conditions.

Fischer-Tropsch Cobalt Catalysts. Influence of Type of Kieselguhrs. ROBERT B. ANDERSON, ABRAHAM KRIEG, BERNARD SELIGMAN AND WILLIAM TARN, *Ind. Eng. Chem.* **40** (1948), pp. 2347-50.

The investigation reported was prompted by a search for a suitable commercially available American kieselguhr for the preparation of cobalt Fischer-Tropsch catalysts. Data are presented for a series of cobalt-thoria-magnesia-kieselguhr catalysts prepared with a number of American kieselguhrs. Catalysts containing calcined kieselguhrs had lower activity than those obtained from natural kieselguhrs. Acid-extracted natural kieselguhrs produced catalysts of the highest activity. The density of the catalyst varied directly with the density of the kieselguhr, and the distribution of products changed with density of the catalysts, the denser catalysts forming a greater percentage of light hydrocarbons and carbon monoxide. A bibliography of 15 references is included.

Synthesis of Tertiary Alkyl Mercaptans. WALTER A. SCHULZE, J. P. LYON AND G. H. SHORT, *Ind. Eng. Chem.* **40** (1948), pp. 2308-13.

A synthetic procedure is described for the production of mercaptans or sulphur alcohols of high molecular weight. The process involves the direct addition of hydrogen sulfide to olefin hydrocarbons in the presence of catalysts. Laboratory results gave engineering design data for the use of solid catalysts—e.g., silica-alumina gel—in the synthesis of mercaptans in the range of 12 to 16 carbon atoms. Supplementary studies were devoted to several process variables, including the type of hydrocarbon feedstocks, the effect of impurities in the hydrogen sulfide and the comparative activity of a number of different solid and liquid catalysts. Dehydration and liquefaction of relatively pure hydrogen sulfide, and the vacuum fractionation of high boiling mercaptans are reviewed and properties of some of the products are summarized. A flow sheet of a mercaptan plant is presented. A bibliography of 13 references is included.

Determination of Mixing of Gas Streams by the Infra-Red Gas Analyzer. R. D. COLLINS AND M. P. NEWBY, British Iron and Steel Research Association, *Nature* **162** (1948), 224.

The technique described has application to any problem of turbulent diffusion between streams of similar gases in which mean concentrations of one gas in the other are to be sampled. The particular application described is the study of mixing of producer gas in the air in an open hearth furnace. Both air and fuel gas, in the model studied, are replaced by air at room temperature. The pattern of mixing between the air from the gas port and that from the air ports was studied. This pattern determines the shape of the flame and the rate of burning, and is of great importance in furnace design. A full-scale deflexion is obtained when using 0.03 percent concentration of carbon dioxide. At the rate of aspiration used, the speed of response of the instrument was more than five seconds for two-thirds final reading.

Diolefins in Alkylation Feedstocks. JOHN ANDERSON, S. H. MCALLISTER, E. L. DERR AND W. H. PETERSON, *Ind. Eng. Chem.* **40** (1948), pp. 2295-2301.

Critical wartime shortage of light olefins for alkylate gasoline manufacture led to studies of the method for increasing the supply of butylenes and amylenes. Materials containing diolefins were available in some quantity and a vapor phase process for changing the diolefins in such materials to mono-olefins by selective hydrogenation was devised. The supported nickel sulfide catalysts used in the hydrogenation process were found to have a remarkable selectivity in that they were active for hydrogenation of diolefins to mono-olefins but relatively inactive for the hydrogenation of mono-olefins to paraffins in the range 200-300° C., and even in the presence of a large excess of hydrogen. Butene and pentene fractions that had diolefin present to such an extent as to render them unsuitable for isoparaffin alkylation were converted to fractions that gave excellent alkylation. Investigation was directed primarily to continuous vapor phase operation under conditions readily obtainable in existing hydrogenation units of the types used for hydrogenating catalytically cracked gasolines or for converting butene dimers to iso-octanes. The catalyst employed was prepared from a commercially available nickel carbonate-alumina merely by treating it with hydrogen sulfide at 400° C. This material proved to have a life of over 1000 hours when treating a C_4 fraction containing 23 mole percent butadiene, and, after losing its activity, it was reactivated by burning and resulfiding.

Principles of Extractive Distillation. EDWARD G. SCHEIBEL, *Chem. Eng. Progress* **44** (1948), pp. 927-31.

The author describes a method for choosing a solvent in extractive distillation, using a systematic approach to the problem based on molecular structure and functional groups on the compounds to be separated. The method will predict a large number of solvents that can be used although other possibilities not apparent by this method may be more effective. The fundamental principles of extractive distillation are discussed and a method is presented for estimating whether components form azeotropes, together with a method for evaluating the relative effectiveness of different solvents in extractive distillation. An approximate method for the design of extractive distillation processes is given by which it is possible to show by quantitative calculations that vapor feed is always advantageous in the extractive distillation column and also to show quantitatively the effect of prefractionation of the feed aand when this prefractionation is unnecessary.

PRODUCTS: PROPERTIES, UTILIZATION AND ANALYSIS

Polar-Type Rust Inhibitors. Theory and Properties. H. R. BAKER AND W. A. ZISMAN, *Ind. Eng. Chem.* **40** (1948), pp. 2338-47.

During the past decade the addition of rust inhibiting compounds to many types of lubricating oils has become a widely accepted practice. Such oils are used to prevent the rusting of iron and steel surfaces exposed during storage or use to water condensed from the atmosphere or present through leakage. The authors discuss the various physical and chemical phenomena involved in the adsorption of polar solutes from nonpolar or weakly polar solvents. The mechanism of rust inhibition caused by polar compounds is analyzed in terms of such properties of the adsorbed molecules as the hydrophobic property, the energy of adsorption, the effect of temperature on the adsorptivity, steric hindrances to close packing, the penetrability of the monolayer by molecules of water and the solubility of the monolayer in water. Rust inhibition obtainable in a reference petroleum oil by the addition of a variety of polar compounds, many of which are exceptionally pure, was observed during using the turbine oil rusting tests at different concentrations and temperatures. The results have been classified and interpreted in terms of the theory outlined and in the light of organic chemical considerations. Conclusions are generalized further by a comparison of the data obtained from some selected polar compounds dissolved in petroleum oils, several pure hydrocarbons, several chlorinated hydrocarbons, a group of aliphatic diesters, some polyalkylene glycol derivatives, and various types of silicone fluids. A bibliography of 30 references is included.

Determination of Polymer in Furfural. J. C. HILLYER AND A. J. DEUTSCHMAN, JR., *Analytical Chem.* **20** (1948), pp. 1146-50.

Although furfural is normally regarded as a stable material and the decomposition rate of refined furfural is low, nevertheless, under the influence of heat and certain process conditions, furfural tends to polymerize slowly. The authors describe work done in the course of the development of a vacuum distillation method of analysis of polymer in furfural and describe the final procedure which is adopted for analysis. An early method, in which the polymer was determined as residue which is left after stream distillation, was found to be erratic and unsatisfactory. Tests show that it gave low results because of polymer losses in the condensed water. A simple vacuum distillation technique was developed, using a special 50-ml. flask, in which constant weight was obtained by several successive evaporations with acetone. This gave good precision and accuracy. It has been used for several years on plant and research samples. Recent changes include slight modifications that increase speed and precision slightly. Addition of a limited fractionating capacity to the neck of the flask made possible accurate analysis of samples containing the intermediate boiling furfural-butadiene copolymer.

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F. S. Clulow, C. S. Gentry and E. C. Peet, all of whom have held executive positions with Shell Oil Company for many years, have been appointed directors.

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Digest of Recent U. S. PATENTS Pertaining to PETROLEUM REFINING

Compiled by HEINZ HEINEMANN

(From the Official Gazette, November 16, 23, 30 and December 7, 1948.)

CRACKING AND REFORMING

U.S.P. 2,454,369. Catalysis of Hydrocarbons. J. R. Bates to Houdry Process Corporation.

Heavier hydrocarbons are cracked in the presence of a calcined composite of precipitated silica containing deposited zirconia and beryllia. Normally liquid low boiling hydrocarbons of the gasoline type are formed.

U.S.P. 2,454,615. Catalytic Cracking of Hydrocarbons. J. A. Ridgway, Jr., and P. Hill to Pan American Refining Corporation.

A hydrocarbon oil heavier that gasoline is cracked by intimate contact with at least 50 percent by weight of a liquid HF catalyst at a temperature of 100-300° C. under a pressure sufficient to maintain liquid phase conditions. Low-boiling isoparaffins and other hydrocarbons of gasoline boiling range are recovered.

U.S.P. 2,455,561. Reducing Disengaging Height in Fluidized Powder Systems. G. D. Creelman to The M. W. Kellogg Company.

A particular process is described for effecting contact between a finely divided solid contact material and a gas, as employed for instance, in the fluid catalyst refining or cracking of hydrocarbon oils.

REFINING

U.S.P. 2,453,853. Separating Hydrocarbons. C. E. Morrell and M. W. Swaney to Standard Oil Development Company.

Butadiene is separated and segregated from a mixture of hydrocarbons which also contains acetylenes by absorbing the acetylenes and the butadiene in an ammoniacal cuprous salt solution, in which the copper acetylides formed are maintained in dissolved form. On heating the rich cuprous salt solution to a temperature of 40-100° F. absorbed butenes are released. On further heating this solution to 140-180° F. while maintaining a reflux temperature of 70-100° F. butadiene only is desorbed. The remaining solution is then stripped with the unabsorbed hydrocarbons at a temperature of 140-180° F. to remove acetylenes.

U.S.P. 2,454,382. Method of Resolving Petroleum Emulsions. J. L. Harlan to Standard Oil Development Company.

A petroleum emulsion of the water-in-oil type is treated with a petroleum sulfonic acid body which has an amino derivative attached to the hydrocarbon nucleus. The emulsion is easily broken by this treatment.

U.S.P. 2,454,435. Process for Breaking Petroleum Emulsions. M. De Groote and O. H. Pettingill to Petrolite Corporation, Ltd.

An emulsion of the water-in-oil type is broken by treatment with an oxyalkylated, drastically-oxidized cashew nutshell liquid.

U.S.P. 2,454,467. Process for Removing Olefins from Aromatic Hydrocarbons. R. M. Love to Standard Oil Development Company.

A predominantly aromatic hydrocarbon feed stock contaminated by not more than 3 percent of olefins is treated in vapor form at elevated temperature with a mixture of aryl sulfonic acid and 90-100 percent conc. H_2SO_4. A vapor phase and a liquid phase are separately removed from the contacting zone. The liquid phase is cooled to at least atmospheric temperature. Separation into a substantially pure aromatic hydrocarbon liquid phase and an aryl sulfonic acid liquid phase is obtained.

U.S.P. 2,454,605. Desalting Crude Oil. C. G. Kirkbride and M. C. Hopkins to Pan American Refining Corporation.

A brine-containing oleaginous liquid, such as salt-containing crude oil, is passed through a bed of fiber glass of a density of 10-20 pounds per cubic foot and an interfiber distance (based on these densities) of 0.0042-0.0084 inch. The oil is desalted by such filtration.

U.S.P. 2,454,808. Reagent and Process for Resolving Emulsions. W. H. Kirkpatrick and D. L. Wilson to Visco Products Company.

A petroleum emulsion of the water-in-oil type is broken by being subjected to the action of a mixed ester derived from the reaction of a polyhydric alcohol and a drying oil, such as tall oil, said ester being blown to a soft, viscous condition.

U.S.P. 2,455,634. Processes of Refining Aromatic Hydrocarbons. P. J. Wilson, Jr., J. H. Wells and C. R. Liebel to Carnegie Steel Corporation.

Aromatic hydrocarbons which contain not more than 5 percent of impurities including paraffinic, naphthenic and sulfur compounds are purified by successive treatment with a dehydrogenating catalyst and a cracking catalyst under defined conditions.

U.S.P. 2,455,679. Distillation of Acid-Treated Oils. M. C. K. Jones and E. C. Eulhart to Standard Oil Development Company.

An acid-treated mineral oil is mixed with 90-95 percent of the stoichiometric quantity of caustic alkali necessary to neutralize any acid reacting substance evolved from any residue of the treating acid during the subsequent distillation of the oil together with a sufficient amount of a naphthenic acid soap to be capable of completing the neutralization.

U.S.P. 2,455,745. Stabilization of Styrene and Polymerizable Ring Chlorinated Styrenes. E. R. Erickson to Mathieson Chemical Corporation.

Polymerization of styrene and ring chlorinated styrenes is inhibited by an addition (e.g. 0.001-5 percent) of 2,5-dialkoxyhydroquinone.

U.S.P. 2,455,746. Stabilization of Vinyl Aromatic Compounds. E. R. Erickson to Mathieson Chemical Corporation.

The method of this patent differs from that of U. S. Patent 2,455,745 only in that the substituents of the 2,5-disubstituted hydroquinone employed consist of alkyl or aralkyl radicals.

U.S.P. 2,455,803. Extractive Distillation Process. G. J. Pierotti to Shell Development Company.

In the extractive distillation of a mixture of aromatic hydrocarbons, e.g. toluene, and non-aromatic hydrocarbons with similar boiling ranges by means of sulfolane, cumene is added in controlled amounts sufficient to produce a single liquid phase instead of the otherwise produced two phases. The efficiency of the extractive distillation is improved by this additive.

U.S.P. 2,455,820. Production of Oil-in-Water Emulsions. A. B. Steiner to Kelco Company.

A stable oil-in-water emulsion is formed by intimately dispersing an oily substance, such as liquid petrolatum, in an aqueous liquid containing a glycol alginate.

U.S.P. 2,455,812. Fractionation in Presence of Radiant Energy. C. H. Schlesman to Socony-Vacuum Oil Company, Inc.

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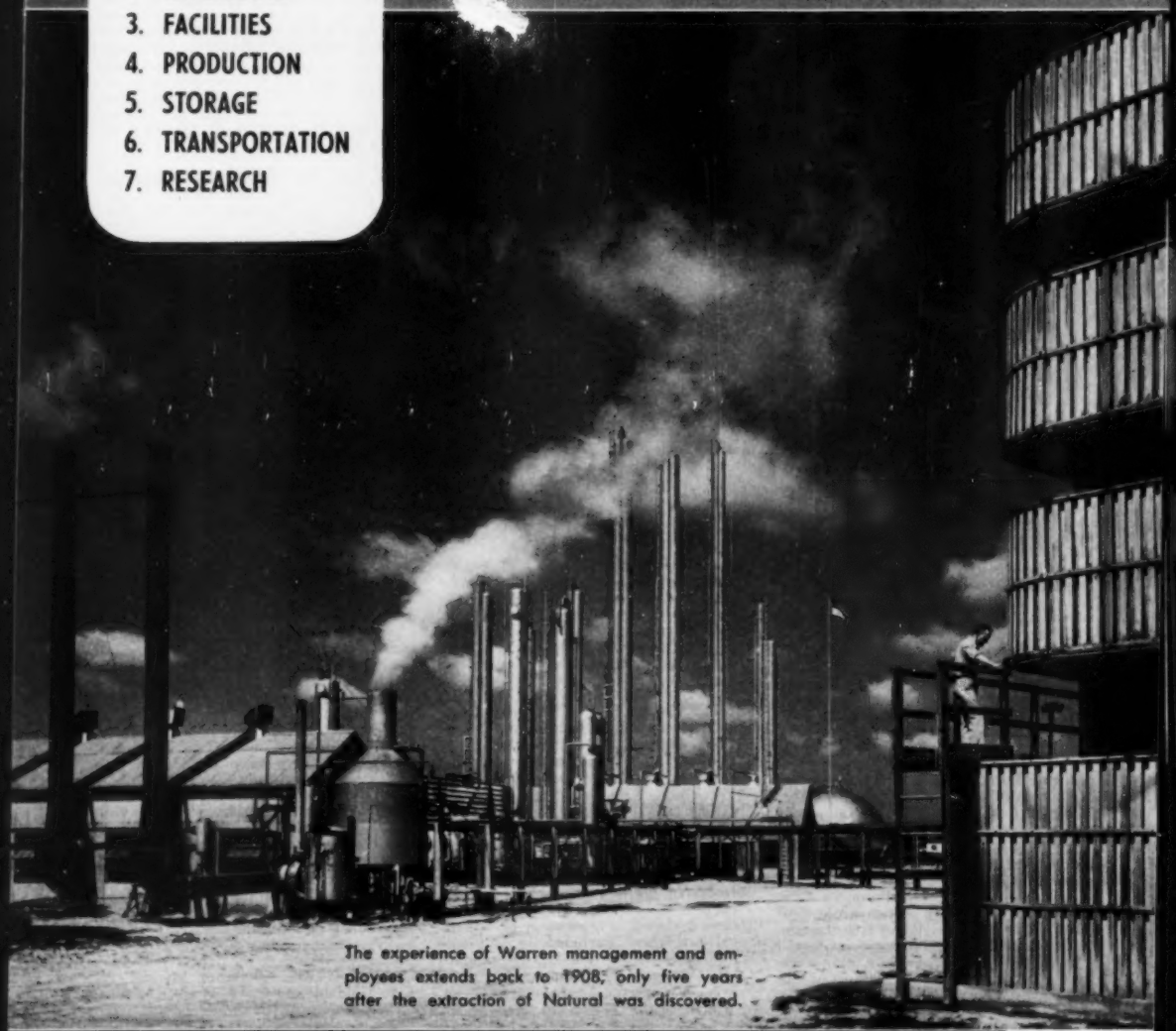

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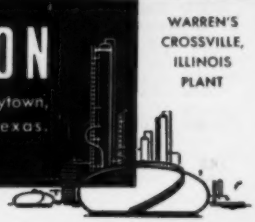

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leum fraction which consists of a mixture of compounds with substantially identical boiling points, the vaporized fraction is subjected to radiations from a selected portion of the radio frequency spectrum. This portion is selected so that at least one of the compounds in the fraction will absorb radiant energy and at least one other will not. The fraction is simultaneously cooled so that the compound that absorbs radiant energy will remain in a vapor state while the other compound will be condensed.

CATALYST PREPARATION, ACTIVATION, AND REGENERATION

U.S.P. 2,453,847. Process for Accelerating Alumina Hydrosol Formation by Aeration. C. N. Kimberlin, Jr., to Standard Oil Development Company.

Alumina hydrosols useful in the production of gel catalysts and catalyst carriers are manufactured from amalgamated aluminum and a dilute aqueous solution of an organic acid by blowing the mixture of these two components with an oxygen-containing gas.

U.S.P. 2,454,227. Beta-Alumina Catalyst. A. E. Smith and O. A. Beeck to Shell Development Company.

An adsorptive beta alumina suitable for use in catalysis is prepared by reacting an alumina of the gamma system of Haber, in the absence of metal oxide isomorphous with alpha alumina, with a compound of Na, P, or Rb decomposable to the oxide by heating at a temperature of 900-1400° C. for at least two hours and until the material shows the X-ray diffraction pattern of beta alumina of the general formula $R_2O \cdot 11\,Al_2O_3$ wherein R represents the alkali metal employed. The resulting catalyst is very stable.

U.S.P. 2,454,373. Fluidized Catalyst Regeneration Process which Includes Overhead Cooling. F. H. Blanding to Standard Oil Development Company.

In the regeneration of finely divided contaminated catalytic material by an oxidizing gas passing through this material at a velocity such that a relatively dense layer of catalyst is maintained in the bottom portion of the regenerator while a relatively dilute phase of spent regeneration gas, entrained catalyst and some excess oxidizing gas is maintained in its upper portion, a second stream of spent catalyst is dispersed into this dilute phase to prevent secondary combustion of CO formed in the regenerating treatment, by the uncombined oxygen contained in the dilute phase.

U.S.P. 2,454,398. Iron Oxide-Alkali Metal Pyroantimoniate Catalysts and Process of Preparation. M. A. Mosesman to Standard Oil Development Company.

A Fischer-Tropsch synthesis catalyst is obtained from a mixture of 80-99.8 percent of iron oxide and 20-0.2 percent of an alkali metal pyroantimoniate. The mixture is heated to a temperature of 1000° F. in the presence of free oxygen. Subsequently, the mixture is contacted with a reducing atmosphere at a temperature of 500-900° F. The resulting catalyst remains highly active over a rather long period of time.

U.S.P. 2,454,466. Regeneration of Fluid Catalysts with Cooling of Flue Gases by Water Injection. E. J. Le Roi to Standard Oil Development Company.

In the regeneration of particle form contact material by oxygen containing gases, a non-combustible vaporizable liquid is injected outside the regeneration zone into the regeneration gases leaving this zone and containing entrained contact particles, combustible material and oxygen, to reduce the temperature of the gases and to control after-burning of the combustible gases.

U.S.P. 2,454,724. Molybdena Catalysts, Their Preparation and Use. M. W. Tamele, V. C. Irvine and J. F. Mahar to Shell Development Company.

Granular molybdena-alumina catalysts, useful for example in dehydrogenation processes, are produced by a process described in detail from massive alumina broken into granules, then activated, desalted and subjected to controlled dehydration and eventually impregnated with a certain amount of molybdenum oxide.

U.S.P. 2,454,901. Control of Temperature in Regeneration of Solid Hydrocarbon Conversion Catalysts. R. E. Vinyard, W. W. Roach and B. Skinner to Phillips Petroleum Company.

Details of a process are claimed for the regeneration of elongated beds of solid deactivated hydrocarbon conversion catalysts, such as a synthetic silica-alumina or a bauxite catalyst, by means of an oxygen containing gas admixed with an inert diluent, such as steam.

U.S.P. 2,454,921. Production of Aluminum Fluoride Gels. H. Heinemann to Porocel Corporation.

Aluminum fluoride gel of high porosity and surface area useful in the conversion and refining of hydrocarbon oils is obtained by digesting alumina with at least an equivalent amount of aqueous HF. The quantity of water in the reaction mixture shall be such as to give HF of 30-40 percent concentration.

U.S.P. 2,454,941. Drying Hydrogel Catalysts by Distilling with Butanol. J. A. Pierce and C. N. Kimberlin, Jr. to Standard Oil Development Company.

Dry absorbent gels to be used for hydrocarbon conversion catalysts are obtained from corresponding hydrogels by mixing the hydrogel with n-butanol, distilling the water from the hydrogel as an azeotrope with the butanol, and removing the residual butanol from the dehydrated gel.

U.S.P. 2,454,942. Preparation of Spherical Adsorbent Particles. J. A. Pierce and C. N. Kimberlin, Jr., to Standard Oil Development Company.

Spherical particles of a natural adsorbent useful as a catalyst in hydrocarbon conversions, e.g. such particles of a highly acid-treated bentonite, are obtained by separately dispersing finely powdered adsorbent and a hydrosol, e.g. alumina sol, in a partially water-miscible liquid, such as n-butanol, and agitating the dispersion until the hydrosol sets to a hydrogel and forms spherical particles of gel and adsorbent.

U.S.P. 2,455,445. Gel Catalyst. M. J. See and J. C. Bailie to Standard Oil Company (Indiana).

Gel catalysts, e.g. silica-alumina gels, are prepared in the form of discrete, smooth spheroids by a particular process from a meta-stable sol over a hydrogel having a tendency to agglomerate on drying.

U.S.P. 2,455,696. Iron Oxide-Alkali Metal Ferrate Catalyst and Its Method of Preparation. M. A. Mosesman to Standard Oil Development Company.

A Fischer-Tropsch synthesis catalyst is prepared from a mixture of an iron oxide and 0.2-20 percent (by weight of the iron oxide) of alkali metal ferrate. The mixture is heated at a temperature of about 1000° F. for four hours in an oxidizing atmosphere. Thereafter the mixture is treated in a reducing atmosphere at a temperature of 700-1600° F. for 24 hours.

U.S.P. 2,455,843. Method and Apparatus for Production of Gel Bodies. H. M. Weir to The Davison Chemical Corporation.

Silica and other oxides hydrosols are gelled by a method claimed in detail.

U.S.P. 2,455,881. Mercury-Treated Charcoal Catalyst and Process for its Preparation. L. F. Salisbury to E. I. du Pont de Nemours & Company.

A catalyst useful in the production of vinyl fluorides from acetylene and HF is obtained by impregnating charcoal with an aqueous solution of a mercury salt of controlled concentration and further treating the resulting material in a manner claimed in detail.

ALKYLATION

U.S.P. 2,453,765. Alkylation Process. D. G. Stevens to The Standard Oil Company of Ohio.

Isobutane is continuously treated with a butene in the presence of a liquid acid alkylation catalyst, e.g. concentrated H_2SO_4, under suitable conditions. A relatively large part of the isobutane is continuously recycled in an isobutane-acid emulsion which re-enters the reaction zone near the entry of fresh feed. A certain rate of recycling is maintained. A high rich mixture rating motor fuel with a very high content in trimethyl pentane is obtained.

U.S.P. 2,453,837. Apparatus for Alkylation. E. J. Fisher, W. B. Franklin and D. A. Smith to Standard Oil Development Company.

The apparatus according to this patent is useful in conducting reactions between a plurality of liquid reactants maintained in a circulating stream in the form of an emulsion.

U.S.P. 2,454,869. Alkylation Method. A. R. Goldsby and C. W. Watson to The Texas Company.

A stream of alkylatable hydrocarbons and a stream of corrosive mobile alkylation catalyst (e.g. $AlCl_3$) are passed in intimate contact through a reaction chamber having permeable walls and maintained under alkylating conditions. A non-corrosive hydrocarbon fluid comprising olefins is intorduced into this chamber through the permeable walls

at such a rate as to avoid undesirably high concentration of olefins in the reaction mixture and to serve as a relatively catalyst-free barrier between the catalyst-hydrocarbon mixture and the walls. Alkylated hydrocarbons are obtained.

U.S.P. 2,455,003. Alkylation of Paraffins in Presence of Hydrofluoric Acid. F. E. Frey to Phillips Petroleum Company.

Low-boiling isoparaffin is alkylated in the presence of HF with recovery of HF in a process the details of which are claimed.

ISOMERIZATION

U.S.P. 2,454,149. Isomerization of Normal Butane. L. U. Franklin and C. F. Plumhoff to Gulf Oil Corporation.

Isobutane is produced substantially free of $AlCl_3$ in a liquid phase process from n-butane mixed with HCl in two consecutive stages. The first isomerizing zone contains solid $AlCl_3$, the second a slurry of $AlCl_3$-hydrocarbon complex. Details of this method are claimed.

U.S.P. 2,454,171. Combination Isomerization and Hydrogenation Process. H. J. Hepp to Phillips Petroleum Company.

A tertiary olefin, such as isobutylene, in a hydrocarbon stream is selectively polymerized to form a dimer having a terminal C to C double bond. This dimer is separated by fractionation from higher polymers formed and unpolymerized material. The purified dimer is passed over an isomerization catalyst comprising brucite at a temperature of 50-450° F., and subsequently catalytically hydrogenated. A paraffin hydrocarbon, such as 2,2,4-trimethylpentane is formed. The method is also useful in the production of paraffins from 1-olefins which are first isomerized to the corresponding 2-olefins and then hydrogenated by means of metallic Ni-Cu-Al_2O_3-catalyst.

HYDROGENATION, DEHYDROGENATION, AROMATIZATION

U.S.P. 2,453,874. Hydrocarbon Synthesis. S. B. Sweetser to Standard Oil Development Company.

A mixture of CO and H_2 is forced upwardly under synthesis conditions through a dense suspension of powdered synthesis catalyst and powdered dehydration catalyst (e.g. alumina) fluidized by the upwardly flowing gases. The dehydration catalyst is concentrated in the upper portion of the suspension. A major proportion of normally liquid hydrocarbons and a minor proportion of oxygenated compounds is formed.

U.S.P. 2,455,419. Synthesis of Hydrocarbons and Regeneration of Synthesis Catalyst. E. A. Johnson to Standard Oil Company of Indiana.

In the hydrocarbon synthesis from CO and H_2 by a fluidized powdered iron catalyst maintained as a dense turbulent suspended phase, a portion of the catalyst is continuously withdrawn from the synthesis zone to an oxidizing zone where it is countercurrently contacted

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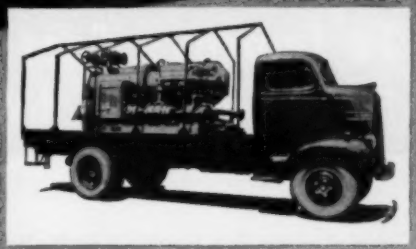

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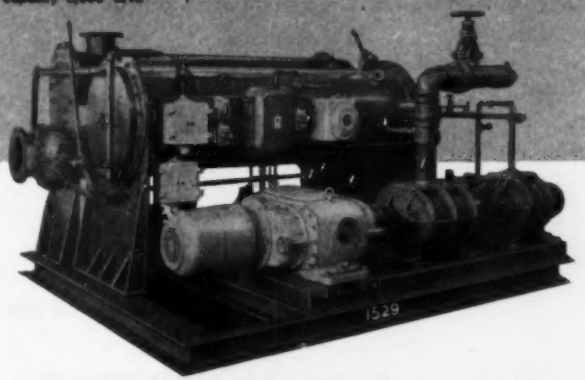

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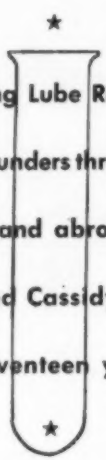

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with an oxidizing medium. The oxidized catalyst is then countercurrently treated with a reducing medium and returned to the synthesis zone after sufficient cooling. The process is useful also in the treatment of S-containing CO-H_2-mixtures.

DESULFURIZATION

U.S.P. 2,454,383. Refining of Hydrocarbon Distillates. J. B. Heid to Universal Oil Products Company.

Hydrocarbon distillate (e.g. gasoline) containing mercaptans, H_2S and carboxylic acids is treated with a dissolved mixture of $Ba(OH)_2$ and caustic of 5-15° Bé to remove H_2S and carboxylic acids, and is thereafter treated with a caustic solution of 15-36° Bé to remove mercaptans. The pretreatment inhibits objectionable foaming in the removal of the mercaptans.

U.S.P. 2,455,061. Treatment of Liquid Hydrocarbons. C. O. Hoover to Air Reduction Company, Inc.

Liquid hydrocarbons are freed from sulfur contained therein in the form of H_2S, mercaptans, or disulfides by treating the hydrocarbons with cuprous naphthenate.

U.S.P. 2,455,656. Production of Commercially Pure Mercaptans and Disulfides. S. P. Cauley to Socony-Vacuum Oil Company, Inc.

Sulfur compounds of commercial purity are produced from petroleum fractions containing mercaptans by means of an aqueous alkaline treating solution which extracts the mercaptans together with impurities of about the same boiling range as these mercaptans. The rich aqueous solution thus obtained is contacted with hydrocarbon washing material of lower boiling range which extracts the mercaptans. The latter are then recovered from the solution formed by distillation. The aqueous solution is regenerated.

POLYMERIZATION AND CONVERSION

U.S.P. 2,455,225. Method of Making Styrene Resin. S. G. Burroughs to Pennsylvania Industrial Chemical Corporation.

Finely divided weakly acid catalytic fuller's earth with a pH of about six and dried at a temperature of 200-250° C. for five minutes is contacted with a styrene liquid of more than 50 percent styrene concentration at a temperature below the boiling point of monomeric styrene in an amount of 1-30 percent catalyst based on styrene. Thermoplastic resin polymers of styrene are formed which are insoluble in aliphatic but soluble in aromatic hydrocarbons.

U.S.P. 2,455,665. Low-Temperature Polymerization Process. W. W. Ford and F. D. Thiel to Standard Oil Development Company.

A mixture of an isoolefin with 4-8 C atoms and a multiolefin with 4-14 C atoms is treated in the presence of a liquid diluent at temperatures of —40 to —150° F. with a Friedel-Crafts catalyst to effect polymerization.

U.S.P. 2,455,671. Process for the Manufacture of High Molecular Weight Polymers. A. D. Green to Jasco, Inc.

Solid isoolefinic polymers are produced and separated by polymerization in the presence of a Friedel-Crafts catalyst in a process described in detail.

U.S.P. 2,455,890. Polystyrene - Mineral Oil Extract Plastic Composition. E. W. M. Fawcett, A. Millien and N. Mulhern to Anglo-Iranian Oil Company, Ltd.

One part by weight of polystyrene is mixed at an elevated temperature with two parts of a hydrocarbon fraction obtained by solvent extracting a high boiling mineral oil fraction of low compatibility with styrene and boiling in the range of 250-800° C. to extract a hydrocarbon fraction of high mol. wt., high compatibility with polystyrene and of other characteristics. The resulting product, in contrast to the very brittle polystyrenes, is highly plastic.

HEAVY OILS AND WAXES

U.S.P. 2,453,708-710. Grinding Oil Composition. E. C. Hughes and F. Veatch to The Standard Oil Company of Ohio.

In U. S. Patents 2,453,708 and 2,453,-710 a grinding composition is claimed which comprises a blend of different types of mineral oil, this blend having a viscosity of 150-300 SSU at 100° F. In the case of U.S.P. 2,453,710 this blend also contains an oil soluble phosphorous compound containing a fatty acid radical with at least ten C atoms. This additive inhibits the development of temper color.

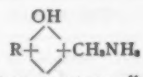
U.S.P. 2,453,709 relates to the grinding of steel with a bonded abrasive in the presence of the composition claimed in U.S.P. 2,453,708.

U.S.P. 2,453,833. Corrosion Preventive. W. S. Davis, Jr., and D. L. Wright to Standard Oil Development Company.

The rust preventing composition according to this patent consists of a mineral oil base which vaporizes completely below 750° F., a corrosion inhibitor formed from a partly volatile sodium petroleum sulfonate combined with degras, and a high mol. wt. polybutene.

U.S.P. 2,453,850. Lubricating Compositions. L. A. Mikeska, A. R. Kittleson and W. M. Smith to Standard Oil Development Company.

Mineral lubricating oil is compounded with a small proportion of an oil-soluble resinous auto-condensation product of an alkyl hydroxy benzyl amine of the formula



in which R represents an alkyl group of at least four C atoms. Rusting and corrosion of metals is greatly reduced by the additive.

U.S.P. 2,453,933. Refining of Wax. P. L. Polizzotto and P. S. Backlund to Union Oil Company of California.

A deoiled asphalt-wax mixture obtained as tank bottoms from crude oil storage and containing more than 5 percent of asphaltic and resinous material is treated at a temperature of 300-350° F. with clay, then cooled to a temperature above its meeting point and contacted with certain alcohol, ketone, or ether solvents. An upper phase formed of wax and solvents is then separated from a lower phase of asphaltic components which also contains the clay.

U.S.P. 2,454,452. Lube Additives Made by Solvent Refining High Molecular Weight Aliphatic-Aromatic Condensation Products. C. E. Hodges and A. F. Cashman to Standard Oil Development Company.

The pour point of a waxy mineral lubricating oil is depressed by the addition of a product obtained from a high mol. wt. aliphatic material with more than ten C atoms, an aromatic compound, and a Friedel-Crafts catalyst.

U.S.P. 2,454,736. Alkaline Earth Metal Petroleum Sulfonate Compositions. J. Faust to L. Sonneborn Sons, Inc.

The patent relates to a non-gelling alkaline earth metal petroleum sulfonate solution in mineral oil, useful for lubricating oils, particularly aviation lubricants. Gel formation of the sulfonate in the solvent is inhibited by an addition of an oil-soluble phthalic acid ester of alkylene glycol ethers, or alkyl phthalates.

U.S.P. 2,454,822. Lubricants for Textile Materials. A. Moscowitz to L. Sonneborn Sons, Inc.

The textile treating agent according to this patent comprises a hydrocarbon textile lubricating oil and 28-40 percent of alkali metal petroleum mahogany sulfonate dissolved therein. Details of the

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method for preparing this sulfonate are also claimed.

U.S.P. 2,454,394. Lubricating Oil Composition. E. Lieber and E. P. Cashman to Standard Oil Development Company.

The lubricant according to this patent comprises a major proportion of waxy mineral lubricating oil and 0.1-5 percent of a condensation product of mol. wt. above 1000 and obtained from about 200 parts of aliphatic nitriles of mixed fatty acids with 16-18 C atoms and 50-100 parts of naphthalene in the presence of $AlCl_3$ and an inert chlorinated hydrocarbon solvent. The additive depresses the pour point of the lubricant.

U.S.P. 2,454,890. Antioxidants for Mineral Oil Lubricants and Compositions Containing the Same. H. G. Smith, T. L. Cantrell and J. G. Peters to Gulf Oil Corporation.

The lubricant according to this patent comprises a mineral lubricating oil and a small amount (e.g. 0.001-1.0 percent by weight) of a non-resinous condensation product of 1-4 mols. of benzyl benzoate, 1-6 mols. of N-dimethylaniline, and 0.5-6 mols. of formaldehyde per mol. of benzoate. Details of the process for producing this condensation product are given.

U.S.P. 2,455,337. Addition Agent for Lubricants. W. A. Jones to Continental Oil Company.

The patent relates to a lubricant which comprises a major proportion of a lubricating mineral oil and 0.01-10 percent of a product obtained from a particular type of petroleum oil, free of naphthenes and the like, by contact with a solid adsorbent, recovery of resinous material deposited on the adsorbent and esterification of this material with alcohol or phenol.

U.S.P. 2,455,649. Solidified Oils and Methods of Manufacture. A. Beerbower and H. A. Ricards, Jr. to Standard Oil Development Company.

The stabilized, solidified oil according to this patent consists of mineral oil gelled by a soap formed in situ from free saturated fatty acids, and stabilized by the saponification in situ of a fatty oil rich in esters of saturated or hydroxylated unsaturated fatty acids.

U.S.P. 2,455,659. Oily Composition. G. W. Duncan and J. C. Zimmer to Standard Oil Development Company.

The oily composition suitable for use as a cutting oil consists of 84 percent mineral lubricating oil, 8 percent sodium petroleum sulfonate, 2.5 percent $NaNO_3$, 2.5 percent naphthenic acid and some minor ingredients.

U.S.P. 2,455,668. Mineral Oil Composition. E. W. Fuller and H. S. Angel to Socony-Vacuum Oil Company, Inc.

A mineral oil composition normally susceptible to haze formation is composed of a viscous mineral oil, a minor proportion of an oxidation stabilizing P- and S-containing reaction product of a dicyclic terpene or an essential oil containing it, and a minor proportion of a wax-substituted hydroxyaromatic ester of a carboxylic acid for suppressing haze formation.

U.S.P. 2,455,670. Deodorizing Petroleum Oils and Waxes. F. M. Graves to Socony-Vacuum Oil Company, Inc.

Moisture-free, odorless petroleum oils and waxes are produced by blowing the moisture-containing petroleum product with air at slightly elevated temperature and then introducing into the moisture-freed product a small amount of ammonia sufficient to remove the rancid odor developed by the air blowing.

U.S.P. 2,455,892. Lubricating Greases and Method of Making the Same. H. M. Fraser to International Lubricant Corporation.

A grease of relatively high m.p. is formed by incorporating in mineral lubricating oil an alkali soap of a high mol. wt. fatty acid and 2.5-12.5 percent of a Na- or Li-salt of acetic acid.

PETROCHEMICALS

U.S.P. 2,453,691. Method of Making Ethyl Chloride. H. W. Hill and E. L. Dance to The Dow Chemical Company.

Ethans exposed to light is reacted at a temperature of 100-200° C. and in the presence of 1/3-3 times its volume of methane with gaseous chlorine in such proportion that the ratio of Cl_2/C_2H_6 is between 0.6 and 1.2. Ethyl chloride is obtained.

U.S.P. 2,453,740. Oxidation of Organic Compounds and Manufacture of Phthalic Anhydride. S. B. Becker to Standard Oil Company (Indiana).

Naphthalene hydrocarbons are con-

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Complete descriptions in Oilco catalog No. 500.

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CHEMICAL COMPOSITION:

(a) The castings shall conform to the following requirements as to chemical composition:

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Chromium, per cent	25.0–28.0
Nickel, per cent	10.0–12.0
Manganese, per cent	0.50–1.25
Silicon, per cent	0.25–1.75
Sulphur, maximum per cent	0.05
Phosphorous, maximum per cent	0.05
Carbon	Within limits of Paragraph 4 (c)

(b) The chemical limits for all other added alloying elements, such as molybdenum, titanium and nitrogen, shall be specified by the manufacturer. The material shall conform therewith.

CREEP STRESS AND CERTIFICATE:

(a) The indicated creep rate of the material shall not exceed 1% in 10,000 hours when stressed by a tensile load not less than the following:

TEMP. °F.	STRESS PER SQ. IN. 1% CREEP IN 10,000 HOURS GRADE "F"
1400°	4200#
1500°	3700#
1600°	3200#
1700°	2600#
1800°	1950#

(b) Manufacturer shall submit standard creep data and residual physical properties made on material of his own manufacture and certified by an ACCREDITED LABORATORY. The chemical analysis of the creep test specimens shall be reported, including nitrogen content and any other special alloying elements.

TENSION TEST FOR DUCTILITY AFTER HEATING:

(a) Each heat shall conform to the following requirements as to tensile properties after the specimen has been subjected to a temperature of 1400° F. for 24 hours and furnace cooled to 400° F. Test shall be made at room temperature.

	GRADE "F"
Tensile Strength, min.lb./sq.in.	80,000
Yield Strength, min.lb./sq.in.	35,000
Elongation in 2", min. per cent	9.0

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verted into phthalic anhydride by means of an oxygen containing gas in the presence of a particle-sized oxidation catalyst, particularly an oxide of a metal of groups V or VI of the periodic system. Details of this method are claimed.

U.S.P. 2,453,779. Preparation of Alkyl Halides. D. C. Bond and M. Savoy to The Pure Oil Company.

A mixture of an olefin and hydrogen halide is contacted with a Th-salt, such as $ThCl_4$, at elevated temperature, e.g. at 200-750° F. Alkyl halides are obtained.

U.S.P. 2,454,034. Process for Preparing Sulfurized Lubricating Composition. D. P. Clark, Jr. to Gulf Research & Development Company.

An oil, e.g. a mineral oil such as 200-SSU, Texas oil, is reacted with sulfur in the presence of a catalyst of the formula AR—NR'—R" wherein R' and R" are hydrogen, lower aliphatic radicals, or monocyclic aromatic radicals, and AR is a benzene ring with a lower alkoxy or monocyclic aryloxy group attached to the ortho or para position. The resulting sulfurized oils are comparatively free from obnoxious odors and have relatively light transparent colors.

U.S.P. 2,454,082. Alkenyl Alkali Metal Compounds. A. A. Morton to Research Corporation.

Alkyl sodium or alkyl potassium, e.g. amyl-potassium, is maintained in intimate admixture with a mono-olefinic aliphatic hydrocarbon with at least three C atoms, e.g. isobutene. Alkenyl alkali metal compounds, such as isobutenyl-1-potassium, are formed and can be readily converted into unsaturated carboxylic acids by treating with CO_2.

U.S.P. 2,454,283. Sealing Element, Including a Binder Consisting of Polyisobutylene and Factice. E. G. King to Armstrong Cork Company.

A sealing element, useful for example as a liner for container closures, consists of polyisobutylene of a mol. wt. of 70,000-200,000 and a large amount of factice.

U.S.P. 2,454,308. Production of Acrylonitrile. H. S. Davis and H. A. Newey to American Cyanamid Company.

Acetylene together with HCN is contacted with an aqueous acid reacting solution of a cuprous salt, $ZnCl_2$, and a salt of ammonium, amine, or an alkali metal salt. Acrylonitrile is produced.

U.S.P. 2,454,351. Production of Alicyclic Carboxylic Acids. F. J. Sowa and A. Schwerdle.

Conjugated dienes, e.g. cyclopentadiene, are contacted with 1,2-unsaturated aliphatic carboxylic acid, e.g. maleic acid, in the presence of a polar solvent for a period not exceeding 90 minutes while maintaining the p.H value of the mixture below seven. Alicyclic carboxylic acids are obtained as addition products of the components.

U.S.P. 2,454,409. Manufacture of Sulfur Compounds. W. A. Schulze and W. W. Crouch to Phillips Petroleum Company.

A liquid mixture of at least one olefin, H_2S and an inert liquid hydrocarbon diluent is contacted with anhydrous HF at a temperature sufficiently low and for a time sufficiently short to effect substantially only the formation of mercaptan.

U.S.P. 2,454,468. Method of Preparing Aromatic Nitro Compounds and Amines. E. H. McArdle to Standard Oil Development Company.

Aromatic hydrocarbons, such as xylene, are nitrated in the presence of an excess of the hydrocarbon, e.g. by a mixture of one part by weight of 75 percent HNO_3 and 1½ parts of 96 percent H_2SO_4 at a temperature of 0-30° C. The resulting mono-nitro hydrocarbons can be hydrogenated after removal of the spent acid and while in solution in an excess of aromatic hydrocarbon to form the corresponding amines.

U.S.P. 2,454,486. Vulcanizable Mixture of Thermoplastic Interpolymers. G. W. Stanton and C. E. Lowry to The Dow Chemical Company.

The patent relates to a vulcanizate useful for shoe soles and formed from a mixture of an interpolymer of 20-80 percent of styrene and 80-20 percent of butadiene with a certain interpolymer of vinylidene chloride and butadiene.

U.S.P. 2,454,645. Production of Alkyl Chlorides. E. G. Galitzenstein and C. Woolf to The Distillers Company, Ltd.

An acyclic aliphatic olefin with not less than three C atoms is passed into H_2SO_4 containing 8-20 percent by weight of water. A reaction mixture of the corresponding alkyl sulfuric esters and free H_2SO_4 is formed. Gaseous HCl is passed into this reaction mixture at a temperature between atmospheric and 60° C. An alkyl chloride-containing up-

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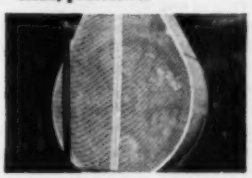

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per layer formed is separated to recover the alkyl chlrodie.

U.S.P. 2,454,737. Copolymers of Hydrocarbon Dienes and Acrylates of Alpha-Hydroxy-Methylethano-9,10 Dihydroanthracene. E. W. Gluensenkamp and A. B. Craig to Monsanto Chemical Company.

The patent relates to a rubber composition obtained by copolymerization of 40-90 percent of a hydrocarbon diene, such as butadiene, and 60-10 percent of a certain type of anthracene compounds, such as (alpha-methacryl-oxymethyl)-9, 10-dihydroanthracene.

U.S.P. 2,454,743. Copolymer of a Conjugated Hydrocarbon Diene and an Acrylate of a Cyclopentadienyl Alcohol. D. T. Mowry and A. B. Craig to Monsanto Chemical Company.

This patent differs from U.S.P. 2,454,-737 essentially only in that, instead of the anthracene derivative, a dicyclopentadienyl alcohol ester of acrylic acid or methacrylic acid is employed in the formation of the copolymer.

U.S.P. 2,454,804. Manufacture of Tetralol. R. Johnson to Koppers Company, Inc.

Tetralin (tetrahydronaphthaline) is controllably oxidized with an oxygen containing gas to form tetralin peroxide. This peroxide is decomposed with an aqueous caustic solution to form alpha tetralol and alpha tetralone. The latter is hydrogenated under pressure in the presence of a Cu-O-Cr_2O_3 catalyst at a temperature of 90-110° C. and is thereby also converted to alpha tetralol.

U.S.P. 2,455,058. Process for Reacting Acetylene and Potassium Hydroxide. D. F. Herman to Publicker Industries, Inc.

Acetylene or a homolog or derivative thereof is passed at a temperature of 50-120° C. into a suspension of finely divided KOH in a water-immiscible organic solvent chemically inert to acetylenes, such as xylene or 1,1-dibutoxyethane. The absorption of acetylene or the like by KOH in the presence of the solvent substantially increases with increasing temperature until a peak is reached.

U.S.P. 2,455,322. Oxynitration of Aromatic Compounds. W. O. Teeters and M. B. Mueller to Allied Chemical & Dye Corporation.

A mononuclear aromatic hydrocarbon, such as benzene or alkyl benzene, is intimately and countercurrently contacted in the liquid phase with nitric acid containing 45-55 percent (by weight) HNO_3 and 2-10 percent Hg $(NO_3)_2$ for a time such that the aromatic phase contains at least 10 percent (by weight) of nitrophenols, which are recovered. Nitro arhydrocarbons, e.g. nitrobenzene and dinitrobenzenes, are obtained as by-products.

U.S.P. 2,455,342. Copolymers of Fumarodinitrile and Styrenes. R. B. Seymour to Monsanto Chemical Company.

A mixture of particular proportions of fumarodinitrile, styrene, and alpha-methylstyrene or alpha-para-dimethylstyrene is copolymerized by heating. A solid, resinous material of high thermal stability and resistance to solvents is formed. It is particularly suitable in

high frequency installations and for conventional radio equipment.

U.S.P. 2,455,425. Production of Nitroparaffins. N. Levy, C. W. Scaife and D. T. Turner Bryson to Imperial Chemical Industries, Inc.

About one volume of isobutane is heated with about two volumes of NO_2 in the vapor phase at a temperature of 190-300° C. The 2,2-dinitropropane and 1,2-dinitro-isobutane obtained are separated by fractional distillation.

U.S.P. 2,454,851. Insulating Material Containing Polysterene and Plasticizer and Method of Making. A. J. Warner and M. Bakst to Federal Telephone & Radio Corporation.

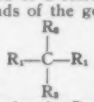
An insulating material is obtained from high mol. wt.-polymerized styrene, low mol. wt.-polymerized styrene, and a plasticizer.

U.S.P. 2,455,601. Production of Solvents. L. C. Morris to Phillips Petroleum Company.

A mixture of air-free steam and highly branched paraffin hydrocarbons, such as obtained by alkylation of aliphatic hydrocarbons, is distilled under non-oxidizing conditions maintained by injecting inert, odorless gas. An odorless fraction withdrawn is blended with a fraction of aromatic alkylate obtained by vacuum distilling the alkylation product of an aromatic hydrocarbon with a high-boiling olefin. A solvent of low-odor intensity is obtained, the solvent power of which is controlled by the proportion of aromatic alkylate therein.

U.S.P. 2,455,643. Condensation Products from Ketones and Aralkyl Organic Compounds and Method for Producing the Same. A. R. Bakalar to Shell Development Company.

An aralkyl hydrocarbon, e.g. toluene, is condensed with an aliphatic ketone, or the like, in the presence of H_2SO_4, a phosphoric acid or a sulfonic acid catalyst. Compounds of the general formula



are obtained wherein R_1 is an aralkyl hydrocarbon radical and R_2 and R_3 are alkyl hydrocarbon radicals, or the like.

U.S.P. 2,455,709. Battery Box Asphalt and Method of Making the Same. W. E. Speishouse and A. H. Boenau to Socony-Vacuum Oil Company, Inc.

A tar obtained by solvent extraction of residual petroleum oil is reduced by by distillation to a material of particular properties. The reduced tar obtained is then oxidized to form an asphalt of properties suitable for its use in the manufacture of battery boxes, insulators and similar articles of high mechanical strength.

U.S.P. 2,455,714. Method for the Coagulation of Emulsion Polymerizates. W. W. Waterman and E. O. Ohsol to Standard Oil Development Company.

A latex obtained by the copolymerization in aqueous emulsion of butadiene, or another conjugated low diolefin, and acrylonitrile, or the like, is treated in a manner described in detail for coagulating the latex.

U.S.P. 2,455,811. Hydroaromatic Sulfonates and Their Preparation. H. Schindler to The Pure Oil Company.

Benzene in which one halogen is substituted with a hydroaromatic radical, e.g. cyclohexyl benzene or alpha-phenyldecalin, is condensed with indene. The resulting product is sulfonated. $AlCl_3$ can be employed as the condensation catalyst. Surface active compounds are obtained which are effective as detergents and emulsifiers.

U.S.P. 2,453,089. Process for Production of Halogenated Olefins. G. H. Morey and R. F. Taylor to Commercial Solvents Corporation.

A gaseous conjugated diene, such as butadiene, is intimately mixed with a gaseous halogen in an unpacked reaction zone in the ratio of 0.8-1.3 moles of halogen per mole of diene. The temperature within this zone is maintained within the range of from 60° C. to a temperature slightly below the boiling point of the lowest boiling halogenated product produced. Dihaloolefins, e.g. dichlorobutenes, are obtained.

U.S.P. 2,453,144. Synthesis of Organic Compounds. W. G. Lovell, M. J. Mulligan, and H. K. Lichtenwalner to General Motors Corporation.

A mixture of 2,3-dimethyl-2-butene and an alkyl halide, e.g. methyl chloride, is passed over fresh lime heated to 200-250° C. until reaction between the reactants is initiated as shown by a rise in temperature of the lime adjacent to

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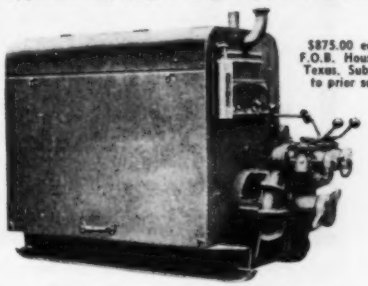

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the entrance of the other reactants. Fresh lime is then introduced continuously at one end of the elongated reaction tube, and the lime is continuously fed through this tube. The mixture of the butene hydrocarbon and alkyl halide is continuously passed countercurrently to the lime through the tube at a temperature of 200-300° C. and at atmospheric pressure. The alkylated olefins produced have an alkyl group added adjacent to the double bond of the charge olefin.

U.S.P. 2,453,298. Synthetic Resins and Preparation Thereof by Reacting an Alkyl Benzene, a Phenolic Compound, and a Dihaloalkane. H. S. Bloch to Universal Oil Products Company.

A three component resin is produced by reacting in the presence of a Friedel-Crafts metal halide catalyst (1) an alkylbenzene hydrocarbon with not more than two alkyl groups of not more than two C atoms, each, (2) a mono- or dihydric phenol or an ether thereof with not more than two alkyl groups of not more than two C atoms in the nucleus, and (3) a dihaloalkane with two to four C atoms. Details, describing the amounts of the components and catalyst required are given. The resins obtained are useful as coating compositions.

U.S.P. 2,453,440. Carbon Black. C. Kaufmann and H. H. Hall to Shawinigan Chemicals, Ltd.

A carbon black of particular characteristics is formed from an endothermic hydrocarbon gas, such as acetylene, by a continuous process the details of which are claimed.

U.S.P. 2,453,558. Printing Ink. A. Voet to J. M. Huber, Inc.

The printing ink according to this patent consists of a pigment (e.g. carbon black), a mineral oil vehicle, and 2-20 percent by weight (based on the oil) of a petroleum polymer, fluid at room temperature and having a viscosity of 200-250 seconds Saybolt at 210° F. This polymer is obtained by solvent extraction of solid adsorbents used in the refining of petrolatums, greases, or amorphous waxes.

U.S.P. 2,453,619. 1,3-Diketones. A. C. Byrns to Union Oil Company of California.

1,3-diketones are prepared by reacting a monoolefin, e.g. a cyclic olefin or an acyclic branched chain olefin with at least four C atoms, with diketone in the presence of an acylation catalyst, such as $ZnCl_2$ or BF_3.

Howard Peterson Elected Vice President of Indoil

Howard R. Peterson has been elected vice president of Indoil Chemical Company, chemical subsidiary of Sandard Oil Company (Indiana). Previously he was sales manager of Indoil and will continue in that capacity. Before the chemical products sales of the parent company were first set up as a separate activity he had been associated with Standard's sales department in various capacities since 1923.

A graduate of the University of Nebraska, Peterson served overseas during World War I, following which he studied at the Sorbonne before returning to complete his studies at Nebraska.

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FREE FLOW NO "CHATTERING"

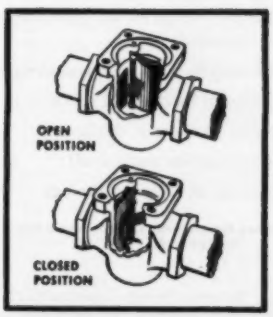
Here's a cast steel high pressure Swing Check Valve for oil, gas, steam and water that will not "chatter" or knock and therefore will outlast ordinary check valves many times.

The gate mounted on a vertical pivot pin does not float on the liquid or gas and its weight therefore is not a factor in closing the valve. NO FLOATING — NO "CHATTERING" — NO WEARING.

When flow ceases or is reversed a flat spring on back of gate forces it closed instantly.

Made of cast steel with large free-flow passage-ways, the Falcon-Greenwood Vertical Horizontal Swing Check Valve is available in sizes from 2" to 8".

Send for Bulletin No. 101



OTHER FALCON PRODUCTS

★ SLUSH PUMP LINERS
★ LINER SLEEVES
★ PISTON RODS
★ SWIVEL WASH PIPES
★ INTERLOCK GLAND PACKING

Falcon Products are sold through leading supply houses everywhere

949-969 EAST SECOND STREET • POMONA, CALIFORNIA
BRANCH WAREHOUSES: HOUSTON • ODESSA • WICHITA FALLS • OKLAHOMA CITY
SHREVEPORT & JEANERETTE, LA. • CASPER • RANGELY • BAKERSFIELD • TURNER VALLEY, CAN.
Export Representative: Guy E. Daniels, 30 Rockefeller Plaza, New York 20, N. Y.

How to cement a "Karbate" threaded pipe joint

1. Thoroughly mix "National" cement with "National" accelerator in recommended proportions.

2. Pour part of the mixture onto a table and work it carefully into the threads of the collar...

3. Then work mixture into pipe threads...

4. Screw collar firmly in place and wipe off excess cement with acetone... the resulting joint is as strong and impervious as the pipe itself!

KEEP "KARBATE" PIPE ALWAYS IN STOCK!

- Resists the action of acids, alkalies and other chemicals
- Light weight with adequate strength
- Resistant to mechanical shock
- Immune to thermal shock
- Easy to machine and install
- Full range of sizes and fittings

For more details, write to National Carbon Company, Inc., Dept. PR

The terms "National" and "Karbate" are registered trade-marks of

NATIONAL CARBON COMPANY, INC.

Unit of Union Carbide and Carbon Corporation

UCC

30 East 42nd Street, New York 17, N. Y.

Division Sales Offices: Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco

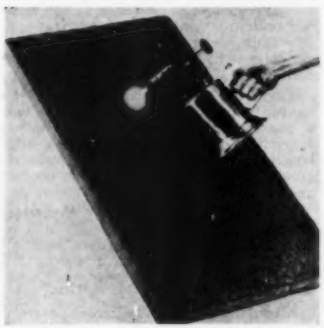
Foreign Department: New York, U. S. A.

These products sold in Canada by Canadian National Carbon Company, Ltd., Toronto 4, Canada

NEW EQUIPMENT and Manufacturers' Literature

For copies of manufacturers' literature or more information on products described on these pages use the number shown for each item.

Low Temperature Insulation

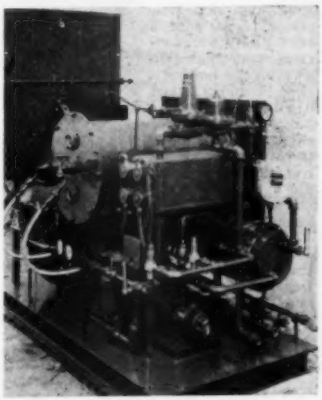


Zerolite, a new low temperature insulation with high fire and chemical resistant qualities, announced by Johns-Manville, is available as sheets, lagging and pipe insulation, and is especially designed for service within the temperatures of 400° and 250° F. It is "an inorganic material that combines high fire resistance, immunity to many organic solvents and excellent moisture resistance with low heat conductivity and will pass the hot rivet test," as described in Maritime Commission specification 32-MC-2; is immune to benzol, methyl, ethyl, ketone and petroleum fractions and derivatives; shows a moisture absorption of 0. After 96 hours in air of 75 percent relative humidity and a water absorption of only 2.0 percent by volume after being submerged for 24 hours; and its low heat conductivity values are 0.28 at 70° F., 0.25 at 0° and 0.22 at minus 70° F. The company recommends Zerolite for the equipment, tanks, vessels and pipes used by the oil and chemical industries where such characteristics are of special importance. Zerolite advantages "are the result of new techniques for processing mineral wool and a special company method of dispersing the resin binder over the mineral wool fibres."

For complete information write Johns-Manville, 22 East 40th Street, New York 16, referring to PETROLEUM REFINER item **41.**

Automatic Burners

New automatic burners of Peabody Engineering Corporation are equipped with a complete system of fuel oil pumping and preheating, fuel oil pressure and temperature regulation, and a constant differential mechanical atomizing oil unit, ready for mounting. Connection of service lines is "the only requirement to complete installation." Equipped with a system of electrically actuated fully automatic safety controls consisting of gas-electric ignition, electronic flame failure protection, solenoid fuel oil shut-off valve, steam pressure limit switch, gas pressure cut-out switch, low fuel oil temperature cut-out switch, and low fire start after each burner shut down, the burner is provided with connections for fuel and steam, gas, and electric power supply. The fan and fuel oil pump are driven by the same motor, the fuel oil pump taking its drive through the speed reduction gear of the motor. The fan is fitted with a vaned air inlet control that regulates the amount of air. The air and fuel oil are synchronized and proportioned by an electric modulating motor which in turn is controlled by an adjustable steam pressure regulator maintaining a constant operating steam pressure within the capacity range of the burner. Control equipment is mounted on a panel board.



For a copy of Bulletin 400 write Peabody Engineering Corporation, 580 Fifth Avenue, New York 19, referring to PETROLEUM REFINER item **42.**

Thy-mo-trol Drive

A Thy-mo-trol drive, known as Type H1, has been announced by General Electric Company in ratings through ½ h.p. The new drive utilizes a simplified half-wave circuit to provide d.c. flexibility from a.c. power. Operating from 220-volt, 60-cycle a.c. (for other voltages a suitable anode transformer is available), it has a 20-to-1 speed range from 1725 to 86 r.p.m. and operates efficiently in ambient temperatures from 50 to 104° F. It is furnished in either the non-reversing or the reversing type, the latter being equipped with a separate magnetic reversing switch. Designed for constant-torque loads, under normal conditions the new drive has excellent speed regulation from no load to full load. The speed may be preset, or may be varied during operation and under load. Dynamic braking permits quick stopping. The electronic panel is mounted in a compact, ventilated NEMA Type 1 enclosure. The equipment is easy to wire since the terminals are located at the front of the panel and separated from the tubes by a protective cover.

For a copy of Bulletin GEA-5179, write General Electric Company, Schenectady 5, N. Y., referring to PETROLEUM REFINER item **43.**

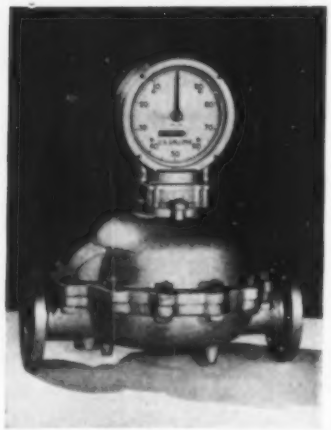
Rotary Positive Blowers

Advantages of the rotary positive blowers of Roots-Connersville Blower Corporation are listed in Bulletin 22-23-B-13 as "keeping air clean by operating without internal contact or friction, having high volumetric efficiencies because the clearances between the impellers and between the impellers and the casing are very small, having low mechanical friction due to the lack of contact between the impellers and the casing, eliminating surface friction because the air velocity through the blower is no greater than that through the pipe leading to the blower and working equally well under pressure or suction

or a combination of both because displacement per revolution is fixed and speed is selected to give the capacity wanted." Performance curves under various operating conditions and gears cut for use with the blowers are discussed in two sections of the bulletin.

For a copy of the bulletin write Roots-Connersville Blower Corporation, 900 West Mount Street, Connersville, Ind., referring to PETROLEUM REFINER item **44.**

Chemical Meters



A new line of stainless steel chemical meters for the volumetric measurement of corrosive liquids is available from Buffalo Meter Company. Capacities range from 3 to 160 gallons per minute, depending on the nature of the liquid. The two models are 1-inch DV and 2-inch GV and are designed for the measurement of such corrosive products as caustic soda, most acids, etc., when metered free from air under 100° F. The meters have working parts of type 316 stainless steel. The measuring piston is made of hard carbon or other materials as required. Outer castings are of 316 stainless steel, cast iron, cast bronze, or high-pressure cast carbon steel.

For further information write Buffalo Meter Company, Buffalo, N. Y., referring to PETROLEUM REFINER item **45.**

Thermometers

The stainless steel thermometer of W. C. Dillon and Company, Inc., has a heat resistant dial which comes in 1, 2¼, 3 and 5 inch sizes. Stem lengths are from 4 to 42 inches. Calibration is for maximum accuracy in Fahrenheit scale but Centigrade ranges are also available. Over-all metal construction "eliminates breakage, makes it possible for the thermometer to be used under conditions of severe vibration, corrosion or shock and to be placed directly in hot materials without reheating." Claimed to work equally well with liquids or gases, and to withstand 3476 psi., the instrument can be screwed into tanks, kettles, steam lines, exhaust systems, air ducts, boilers, refrigerators or it can be floated in open tanks with cork support.

For a copy of Bulletin F write W. C. Dillon and Company, Inc., 5410 West Harrison Street, Chicago 44, referring to PETROLEUM REFINER item **46.**

Heat Exchangers

Two new heat exchangers are available from National Carbon Company. Recommended for heating or cooling corrosive fluids, particularly in tanks with liquid depths up to 16 inches, Karbate impervious graphite heat exchanger, style FH, size 1¼ is designed for horizontal operation. Karbate graphite "has high thermal conductivity (three times as high as carbon steel) and resistance to the action of most acids, alkalis and other corrosive, solvent or reducing agents and particularly to all concentrations of hydrochloric acid and nearly all concentrations of hot sulphuric, phosphoric and acetic acids, wet chlorine and the organic solvents."

The Karbate seven-tube impervious graphite shell and tube heat exchanger, Series 70A, is a redesign of the previous series 70. Basic elements of the new unit "may be converted from a single-pass to a double-pass unit by a change of covers and the exchanger can be better adjusted to varying rates of flow and amounts of liquid handled. Easy replacement of tubes in the field is claimed. Sizes having effective outside tube areas of 16.4 and 24.6 square feet are available.

Complete information may be obtained by writing National Carbon Company, Inc., 30 East 42nd Street, New York 17, referring to PETROLEUM REFINER item **47.**

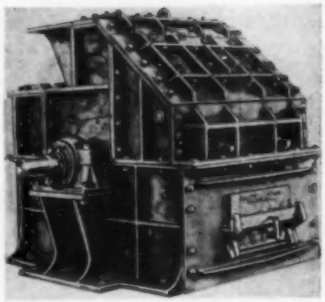
Plug Type Globe Valve

A new plug type bronze globe valve for 300 pounds service has been developed by Jenkins Brothers, one feature of which is the armor seat and slip-on, stay-on plug. Plug and seat ring are of JX500, a special alloy stainless steel, heat treated to give proper hardness (500 Brinnell) and high ductility. The plug has a T-slot for engaging the spindle head and to permit free flow. The spindle has a large diameter and a 15.9-inch thread for the 1-inch size. Nine threads are in contact at all times which assures less load per thread and longer wear, according to the manufacturer. Dimensions of body, bonnet and bonnet ring make them capable of withstanding rough usage and containing high pressures. A deeper stuffing box holds more packing, prevents leakage and assures friction-free spindle operation. The valve is available in sizes from ¼-inch to 2 inches.

For a copy of Form 193, describing the valve, write Jenkins Brothers, 80 White Street, New York, referring to PETROLEUM REFINER item **48.**

Oil Shale Crusher

Designed to reduce any hardnesses of friable materials uniformly and at high tonnage, the high capacity crusher of American Pulverizer Company has been developed for oil shale reduction purposes. Claimed to be capable of reducing 250 tons of oil shale per hour, the new model ACS Hammermill has extra heavy construction with all crushing



parts of manganese steel and joints machined for dust-tightness. Three hammer types "assure an efficient and flexible reduction action to fit each specific operating demand." Hammers are reversible, with two crushing surfaces for double life.

The crusher is available with either a conventional front feed that produces a coarser finished product—or with a specially designed center feed that lengthens the travel of the shale in the crushing cycle giving a finer product and more rapid reduction.

For further details write American Pulverizer Company, St. Louis, Mo., referring to PETROLEUM REFINER item **49.**

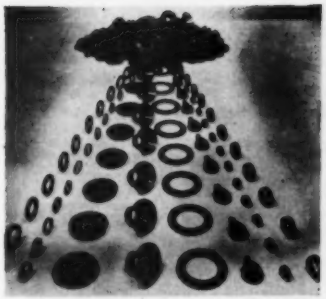
Motor Starters

Alternating-current full votage starters to meet the requirements of any type of motor drive are described in Bulletin 14B7132 released by Allis-Chalmers Manufacturing Company. Construction features and uses of manual and magnetic across-the-line starters, across-the-line combination starters, reversing starters and push-button control stations are all described and illustrated. Two types of thermal relays are used to protect Allis-Chalmers starters from overload, melting alloy relays through size 3 and spiral bimetallic on sizes 4, 5, 6 and 7. Allis-Chalmers produces across-the-line motor starters in five different types of enclosure and in the open type, all constructed in accordance with Underwriters' Laboratories and National Electrical Manufacturers Association recommendations.

For a copy of the bulletin write Allis-Chalmers Manufacturing Company, 1126 South 70th Street, Milwaukee, referring to PETROLEUM REFINER item **50.**

Synthetic Rubber Compounds

The Stalwart Rubber Company has developed a group of new synthetic rubber compounds claimed to resist the chemical action of petroleum products, their derivatives and other industrial and commercial lubricants. Buna N, Hycar or neoprene-based, the compounds can be fabricated into gaskets, sleeves, washers, tubing, molded products and extruded cross sections. Rubbers having tensile strength from 500 to 2500 psi., durometer hardness from 40 to 90, and elongations from 100 to 600 percent can be supplied according to specifications. Various oxident additives will provide weatherproof qualities in the compounds, and these rubbers are also capable of withstanding temperatures ranging from —60 to 225° F., the manu-



facturer has stated. Stalwart compounds can be formulated to meet either SAE requirements or specific applicational needs.

For further information write The Stalwart Rubber Company, 189 Northfield Road, Bedford, Ohio, referring to PETROLEUM REFINER item **51.**

Refrigeration Oil

An all-purpose refrigeration oil suitable for refrigeration and air conditioning applications has been introduced by Ansul Chemical Company. It is claimed the oil does not separate wax down to minus 700° F. in oil-refrigerant mixtures, and will not decompose to form sludges or acids.

For further information write Ansul Chemical Company, Marinette, Wis., referring to PETROLEUM REFINER item **52.**

Frost Proof Hydrant

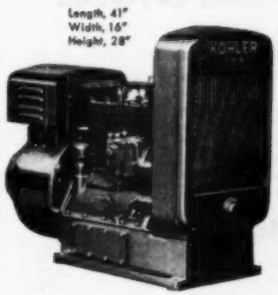
A new design in "frost-proof" hydrants, eliminating the need for underground pits, gravel boxes, drainage lines, sump pumps, special insulation and electric heating coils has been introduced by Crane Company. Inside the riser-spout, for the entire length of the hydrant to well below the frost line, is a rubber tube. When the valve is opened, the water flows through this tube, causing it to expand against the inside of the riser-spout. When the water pressure is turned off, the rubber tubing, which is installed under tension, contracts to an internal diameter not much greater than the thickness of a lead pencil. In cold weather this thin column of water freezes out whenever the valve is opened, water pressure again expands the tubing; and water flows up and around the "pencil" of ice. The ice breaks up and flushes out with the water. The valve is of the composition disc type, operated by a lever at the top of the hydrant. Standard length is 5½ feet. For variations in frost-line depth the hydrant can also be furnished to order. The open end of the spout, which is of one-inch pipe, is threaded with standard pipe threads for attaching a hose adapter. The entire unit is easily disassembled without digging it up.

Protect against power failure! Install stand-by

KOHLER
Electric Plants
at all important operation points

IF wind, sleet, hail, fire, flood or other mishap should wreck the power lines which provide your central station electric current, what protection would you have?

At the world's largest refinery this important problem has been solved by the installation of Kohler Electric Plants at key operating points for emergency lighting, control instruments, alarm signals and other motor driven equipment. When central station current stops, the Kohler Electric Plants take over the load automatically, without human attention, preventing delays, confusion, and possible heavy losses.



Kohler Electric Plant 3A21, 3KW, 115 volt AC, Automatic start and stop.

Kohler Electric Plants have earned a world-wide reputation for reliability. They are specially engineered for emergency stand-by use and are standard equipment in many factories, stores, schools, theatres, homes, and other places. Sizes 750 watts to 10 KW. Write for folder D-14. Kohler Company, Kohler, Wis. Established in 1873.

KOHLER OF KOHLER

PLUMBING FIXTURES • HEATING EQUIPMENT • ELECTRIC PLANTS

FOR DEPENDABLE LIQUEFIED GAS SERVICE...

Specify LUNKENHEIMER N-M-D VALVES

Fig. 402 Lift Check

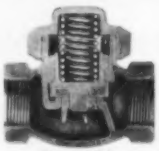


Fig. 403 Lift Check With Spring

400 LB. W.O.G.

FOR Liquefied Petroleum Gases... in LP-Gas systems, bulk transfer and storage tanks, domestic cylinder charging manifolds, vapor differential compressors and the many industrial uses . . . Lunkenheimer 400 lb. W.O.G. (Water-Oil-Gas) Globe, Angle and Check Valves meet every need.

Designed for this particular service and reflecting Lunkenheimer Quality throughout, these rugged valves have special packing and a special, easily renewable non-metallic disc. They seat tight and stay tight. These valves are approved by Underwriters' Laboratories, Inc., for Liquefied Petroleum Gases. Write for Circular 576, or ask your Lunkenheimer Distributor for a demonstration of Fig. 400 "N-M-D" Valves for Liquefied Petroleum Gases. Lunkenheimer Distributors are located in oil producing and refining centers.

ESTABLISHED 1862

THE LUNKENHEIMER CO.

—"QUALITY"—

CINCINNATI 14, OHIO, U. S. A.

NEW YORK 13 · CHICAGO 6

BOSTON 10 · PHILADELPHIA 34

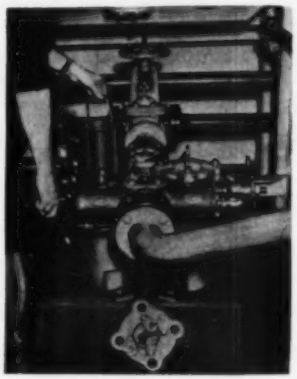
EXPORT DEPT., 318-322 HUDSON ST., NEW YORK 13, N. Y.

LUNKENHEIMER VALVES

BRONZE, IRON, STEEL, AND CORROSION RESISTANT ALLOY VALVES
AIR DEVICES, LUBRICATORS, AIRCRAFT FITTINGS

For information write Crane Company, 836 South Michigan Avenue, Chicago 5, referring to PETROLEUM REFINER item **53.**

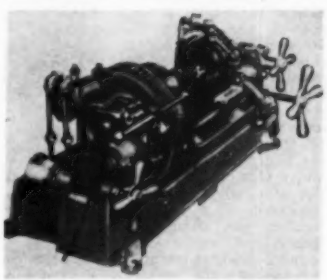
Duplex Strainer



J. A. Zurn Manufacturing Company's new duplex strainer is designed for the flow of fluids having a high solid content without interrupting pipe line operation to clean the strainer. Suitable for intermittent as well as continuous flow, the unit has flexibility of design permitting the handling of sudden surges of solids. Flow through the unit is diverted from one straining chamber to another by a handwheel without the possibility of any positive shut-off. It is adapted to high open area ratio and is suitable for a wide range of pressures and temperatures. Valve seats are removable and valve stems are supported at both ends. The strainer basket is set eccentrically so that the flow section is proportional to the flow needs at all points.

For further information write Department Z-5, J. A. Zurn Manufacturing Company, Erie, Pa., referring to PETROLEUM REFINER item **54.**

Portable Threading Machine

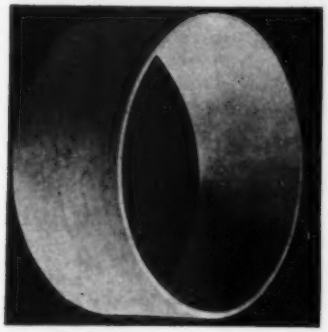


Model B, portable power tool of Beaver Pipe Tools, Inc., has power to thread ⅛ to 2-inch pipe, ¼ to 1½-inch bolts, and with drive shaft and geared tools it will thread up to 8-inch pipe. It weighs 225 pounds and operates with a universal AC or DC motor of 110 or 220 volts—25 to 60 cycle. The pipe threader has an automatic switch lock and chuck wrench holder and an eccentric spool pipe-steady (independent of

spindle) absorbs the "whip" of long lengths of revolving pipe. Gear-driven oil pump provides ample flow of coolant, insuring long die life. Other advancements are quick-opening, fully adjustable, ring-type dieheads; ball-bearing, self-centering wheel-and-roller cut-off; motor with reversible switch and right-hand operation.

For further information write Beaver Pipe Tools, Inc., 1001 Dana Avenue, Warren, Ohio, referring to PETROLEUM REFINER item **55.**

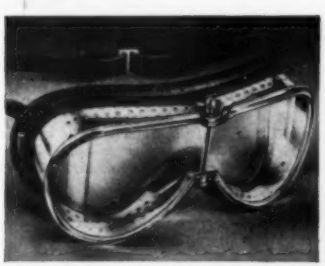
Reinforced Sleeve



The Connecticut Hard Rubber Company has developed a new fiberglas reinforced silicone rubber flexible sleeve for aircraft service which may also have good applications in process plant service. The sleeve as presently designed is used as a flexible connector between lengths of air duct in aeroplanes. It is said that the sleeve permits the passage of air at temperatures of 550° F., will withstand internal pressures of 5 to 10 psi. without leakage, and that it will remain flexible down to —75° F. The specifications call for a test that subjects the sleeve to —65° F. for a period of 50 hours, followed by 500 hours at 400° F. and 5 hours at 450° F. without failure. The sleeves are available on a custom basis in various sizes and widths for applications requiring a flexible connection with extreme temperature resistance range.

For further information write The Connecticut Hard Rubber Company, 407 East Street, New Haven, Conn., referring to PETROLEUM REFINER item **56.**

Goggles



The AO Panoram goggle is available with rubber cushions to provide extra wearing comfort, American Optical

DURALOY

High Alloy CASTINGS

X-rayed by 250,000 Volts

...And we also have Gamma-ray inspection of castings!

Working on the theory that the production of sound high alloy castings calls for more than metallurgical and foundry skill, we have carried out a modernization program in our shop to make it "the last word" in chrome-iron and chrome-nickel production facilities.

Complementing the X-ray and Gamma-ray inspection facilities, we have seven of the latest type electric furnaces (5 arc-type and 2 high frequency type) with capacities ranging from 100 to 6500 pounds per furnace. We have sand-control and sand-treating apparatus. We have one of the best control and analytical laboratories in the industry.

Send for our General Catalog 4729-G

If you would like to have your chrome-iron or chrome-nickel castings made in our modern well-equipped foundry by experienced metallurgists and skilled foundrymen, we shall be glad to take care of your order.

THE DURALOY COMPANY

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Los Angeles & San Francisco: KILSBY & HARMON

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METAL GOODS CORP. • Houston • Dallas • Tulsa • New Orleans • Kansas City

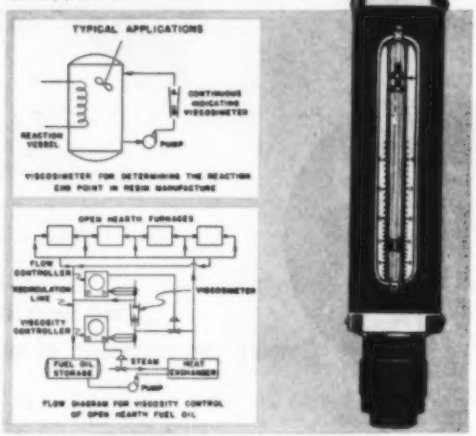
VISCOSITY MEASUREMENT

CONTINUOUSLY AUTOMATICALLY

(and with automatic control of the viscosity, if desired) RIGHT IN THE PIPE LINE, WITHOUT WITHDRAWAL OF FLUID SAMPLES, WITHOUT STOP-WATCH READINGS OF EFFLUX TIMES

NOW AN ACCOMPLISHED FACT

Viscosimeters have graduated from the class of laboratory test instruments to full-fledged industrial instruments which perform their function without manipulation by an operator, just as temperature, pressure, flow and level instruments have been doing for many years.



PRINCIPLE OF OPERATION

Continuous viscosimetry has been accomplished by utilizing one of the unique properties of the F & P FLOWRATOR meter (formerly rotameter): ability to make metering floats either viscosity sensitive or viscosity immune. Into one FLOWRATOR are placed two metering floats, the one so shaped that it is very viscosity sensitive, the other one with the patented F & P viscosity immune shape. When fluid flows upward through the tapered metering tube both floats will, of course, rise in the normal manner. However, the elevation of the one float will be relatively slight, since it is produced solely as a function of fluid flow rate. The other float elevation will be much greater since it is a function both of viscous drag and flow rate. The space increment thus created between the two floats is a direct measure of viscosity. By selecting any particular flow rate which will give a convenient elevation of the one float to serve as a reference line, the other float elevation may be marked as viscosity graduations in terms of centipoises, centistokes, S.S.U. or any other desired units. Viscosity measurement all the way from .0008 to 800,000 centipoises is now possible.

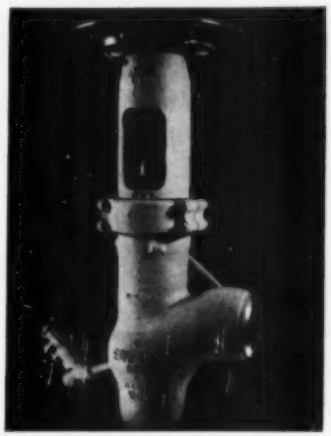
Write for catalog 88 giving much additional information. F & P VISCORATOR continuous viscosimeters have been thoroughly tested in trial installations for well over a year.

FISCHER & PORTER CO.
DEPT. 9M-1C HATBORO, PA.

FLOWRATOR
TRADEMARK

Company has announced. Cushions are molded to the exact shape of the Panoram eyecup and can be slipped into place easily with no need for stapling, sewing or cementing. Once in place, they stay, but can be replaced in a few seconds. Made of soft, pliable, nontoxic, neoprene sponge rubber, the cushions give extra protection against dust and flying particles.

For further information write American Optical Company, Southbridge, Mass., referring to PETROLEUM REFINER, item **57.**



Cast Steel Valves

A new design for cast steel valves has been developed by Edward Valves, Inc., which the company claims makes it possible to install a size smaller valve in pipe lines. Stop and nonreturn valves in either the globe or angle design use the new body for all sizes six inches and above in 900, 1500 and 2500-pound classes. They are available with with pressure-seal or bolted bonnet and with flanged or welding ends. Pressure loss in the new body design is decreased, according to the manufacturer, by streamlined internal contours which eliminate wear producing turbulence, by reduction of weight in all floating parts and by equalization of pressures in all internal areas of the valve.

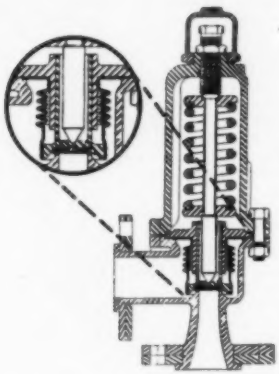
Details of the new design may be obtained by writing Edward Valves, Inc., East Chicago, Ind., referring to PETROLEUM REFINER item **58.**

Temperature Ratings

Tempil® Corporation has developed additional temperature ratings of Tempilstiks® (crayons), Tempilaq® (liquid) and Tempil® Pellets to provide industry with a fuller range of these temperature-indicating products. All three are now available in 12½° intervals from

113° to 400° F. From 400° F. to 1600° F. Templestiks° and Tempilaq° are available in 50° increments while Tempil° Pellets can be had up to 1700° F.

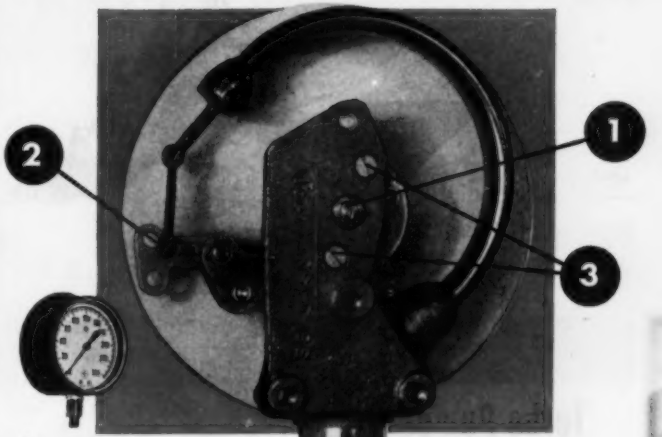
For further information write Tempil° Corporation, 132 West 22nd Street, New York 11, referring to PETROLEUM REFINER, item 59.



Safety Valve

The FarriSeal Bellows, a new type of safety valve construction that "completely isolates the lading fluid from the valve spring chamber and guide surfaces," has been announced by Farris Engineering Corporation. It is claimed that the guide cannot become fouled under any conditions and that corrosion becomes greatly minimized. An enveloping bellows that is built into the valve itself, it is made in type 316 stainless steel as a standard and is also available in rubber and neoprene for chemical and corrosive-resistant types valves. The bellows "is constructed to allow the safety valve its full stroke plus over travel and yet not reach the stress limits of the bellows themselves, as well as to prevent any gases or liquids from entering

The Easiest Gage to Calibrate!

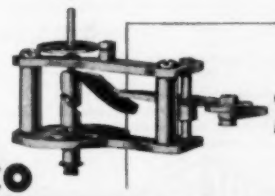


So says the Instrument Engineer

Here's Why: The external pointer set (1) is handy and very useful. In no other gage can the pointer be set without removing the glass and ring. Often a HELICOID gage can be made accurate simply by resetting the pointer.

If recalibration is necessary, the complete gage system is removed from the case. But there is no need to remove the pointer or dial. All adjustments are conveniently at the rear. For pointer travel, the link screw (2) is moved inward or outward in the cam slot. For scale linearity the movement is rotated by loosening screws (3). All this can be done *quickly* with a Helicoid gage. When recalibrating other gages, the pointer and dial must be removed frequently until calibration is attained. This takes more time and costs money.

The HELICOID gage is the easiest to calibrate and the easiest to keep in calibration.



Only Helicoid Pressure Gages have the Helicoid Movement

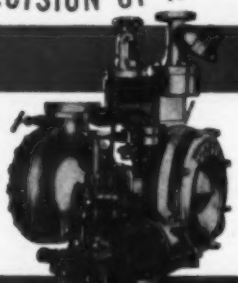
ACCO

HELICOID GAGE DIVISION
AMERICAN CHAIN & CABLE
Bridgeport 2, Connecticut

TRADE MARK

COFFIN

Turbo Pumps Deliver 3-to 12-Stage Pump Performance



COFFIN PUMP REPRESENTATIVES SERVE ALL OF AMERICA'S INDUSTRIES

I. O. Atringdale, New York, N. Y.
Robert Bacon Company, Newton, Massachusetts
Beeson Bros. Engineering Co., Los Angeles, California
Stuart D. Brown, Sewickly, Pennsylvania
The H. Berry-Detroit Company, Detroit, Michigan
Cordes Brothers, San Francisco, California
J. M. Costello Supply Co., Wilmington, California
John N. Fehlinger Co., New York, N. Y.
Fuel Economy Engineering Co., Saint Paul, Minnesota
J. W. Himmelsbach, Chicago, Illinois
International Railway Supply Co., New York, N. Y.
C. E. Johnson & Associate, Atlanta, Georgia
William F. Lewis, Kenmore, New York
Maleson Company, Philadelphia, Pennsylvania
John H. Marvin Co., Seattle, Washington
John H. Marvin Co., Portland, Oregon
The O'Fallon Co., St. Louis, Missouri
Charles Ostertag, Indianapolis, Indiana
Henry P. Thompson Co., Cincinnati, Ohio
P. Thompson Tool & Supply Co., Houston, Texas
Frank D. Riggio Co., Rutherford, N. J.
Seaboard Equipment Co., Yarmouth, Maine
William P. Little, Bridgeport, Conn.
Warren M. Wilson Co., Cleveland, Ohio
Marine Specialty Co., Mobile, Alabama
P. Thompson Tool & Supply Co., New Orleans, Louisiana

FREE

A complete 4-page illustrated bulletin on COFFIN TURBO PUMPS with all operating data, applications, specifications, that you may require for your next job. Write for Bulletin "S" today.

165

INDUSTRIAL RAILROAD COFFIN MARINE

The J. S. COFFIN, JR., COMPANY

326 SOUTH DEAN STREET, ENGLEWOOD, NEW JERSEY

the spring chamber." This "does not retard the operations of the valve." Complete graphs are set up allowing the user to deteremine the point at which the valve is to be set in order to eliminate the error of back-pressure surge.

For information write Farris Engineering Corporation, 484 Commercial venue, Palisades Park, N. J. referring to PETROLEUM REFINER, item **60.**

Induction Motors

Design X, a new line of extra low starting kva squirrel cage induction motors by Electric Machinery Manufacturing Company, is available in flange-mounted or coupled two-bearing types for direct coupling to 514, 600 and 720 rpm air compressors. This motor permits full-voltage starting (across the line) with a starting kva of only 425 percent, according to the manufacturer. It is available in 60-250 hp.

For a copy of Bulletin 195 write Electric Machinery Manufacturing Company, Minneapolis 13, Minn., referring to PETROLEUM REFINER item **61.**

Metal Primer

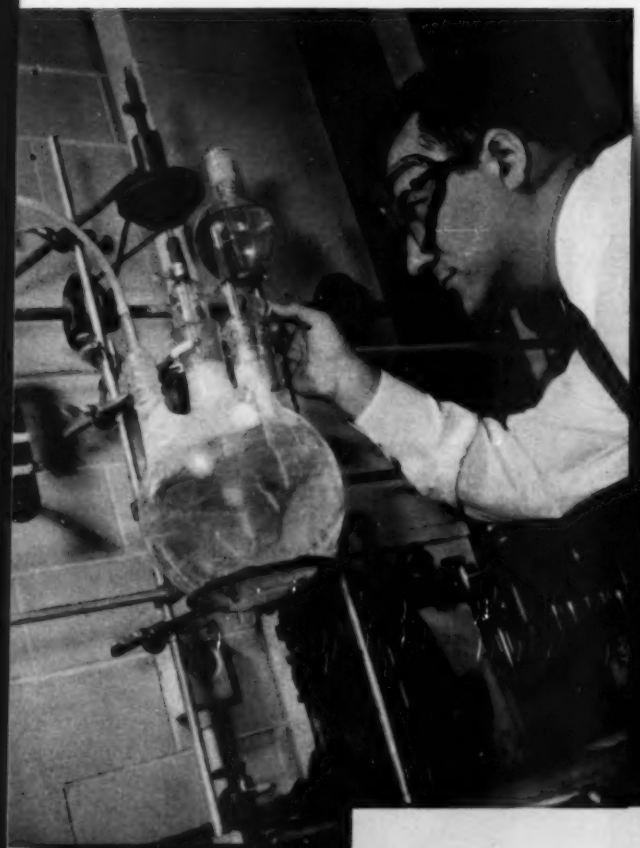
A new surface primer for painting has been developed which claims to eliminate the necessity of having to remove all rust or to have the surface perfectly dry before painting. The combination chemical pretreatment and primer for metal, called Rust-O-Primer, has a vinyl base, quick drying wet primer applicable over wet or dry, clean or rusted metal including steel, aluminum or galvanizing. Its purpose is to provide a hard, paintable foundation for any type of paints including ship-bottom paints as well as acid-causticbond vinyl type of finish.

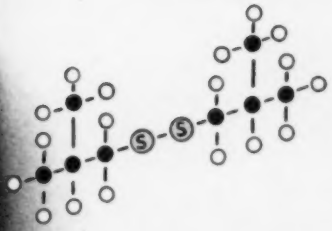
For further information write The Wilbur and Williams Company, Greenleaf and Leon Streets, Boston 15, referring to PETROLEUM REFINER, item **62.**

Toggle Valve

Hoke Incorporated's new toggle valve is available in sizes of ⅛, ¼ and ⅜ inches in brass and ⅛ and ¼ inches in stainless steel. According to the manufacturer, the valve is designed for quick, positive action in opening or closing, and is suitable for pipeline installation

DUPONT TETRAETHYL LEAD COMPOUNDS





Du Pont Research

at Work on the

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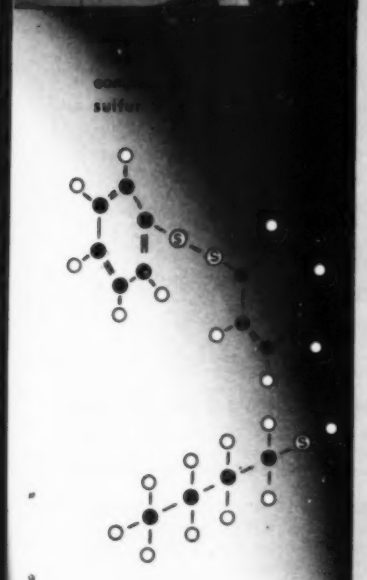


To understand better the mechanism of the anti-knock action of tetraethyl lead, and to improve the efficiency of its use, Du Pont has undertaken a broad program of research. Among the problems being studied is an investigation into the effect of sulfur compounds upon the octane number of leaded fuels.

It has long been known that sulfur, even at the relatively low concentrations that occur in present day motor fuels, causes a significant reduction in the octane number of gasolines containing tetraethyl lead. However, the chemistry of the effects of sulfur compounds in leaded fuels has not been well understood. The many phases of this problem are being thoroughly investigated, applying chemical experience acquired over many years.

This is another example of Du Pont working to help the petroleum industry produce better petroleum products at the lowest possible cost.

DU PONT

Better Things for Better Living . . . Through Chemistry

Research...

to Help Every Refiner

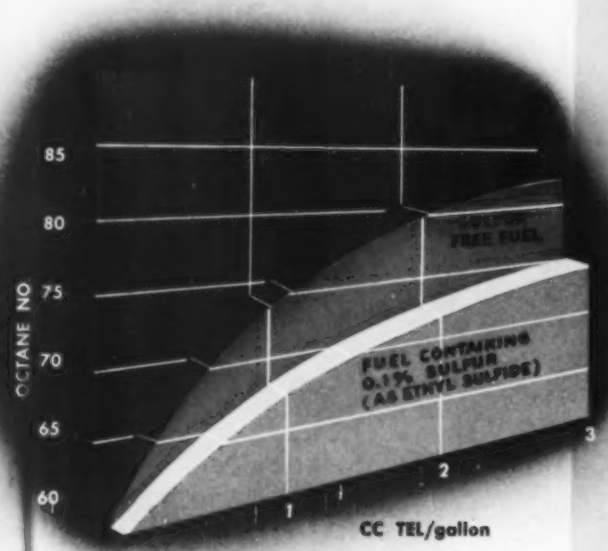


CHART SHOWING EFFECT OF SULFUR ON TETRAETHYL LEAD EFFICIENCY IN A 60 OCTANE REFERENCE FUEL

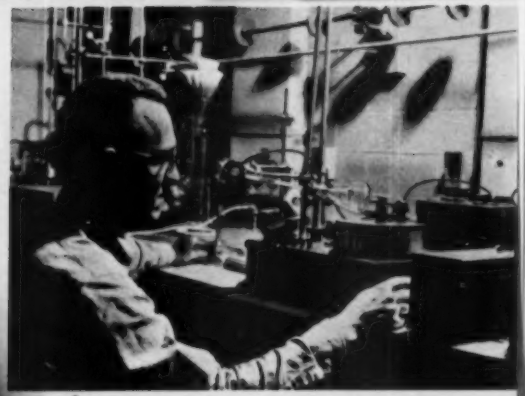
Among the problems of vital concern to the refiner is the improvement of tetraethyl lead efficiency in gasolines containing sulfur compounds. While the effect of sulfur on octane number in non-leaded fuels is insignificant, in leaded fuels it is pronounced and the chart graphically illustrates this.

Tetraethyl lead efficiency in sulfur-containing fuels can be improved by reducing the sulfur concentration. The efficiency of TEL is also dependent upon the type of sulfur compounds present, some having a more adverse effect on octane number than others. Du Pont research is working toward a better understanding of the anti-knock action of tetraethyl lead in the presence of sulfur, as well as improving the efficiency of TEL's use.

The first of a series of technical papers on the subject of sulfur in leaded fuels, prepared by Du Pont research men, entitled "The Effect of Sulfur Compounds on Octane Number of Leaded Fuels—Part 1" is now available. Write the nearest District Office for your copy.

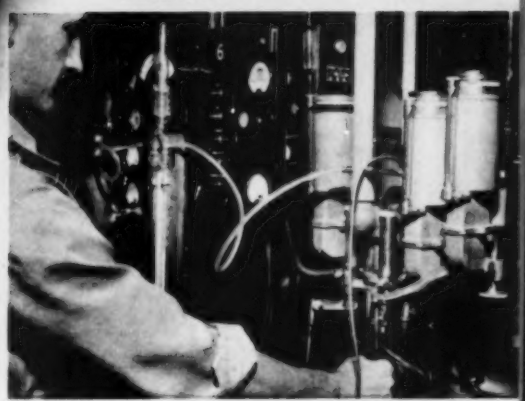
DU PONT

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*



▲ Apparatus used for laboratory experiments on sulfur.

▼ CFR engine equipped for special tests to study effect of sulfur on octane number.



MAKE DU PONT THE SOURCE FOR ALL OF YOUR GASOLINE ADDITIVES . . .

- ***Tetraethyl Lead Compounds***
  Aviation Mix—Motor Mix
- ***Antioxidants***
- ***Metal Deactivator***
- ***Dyes***

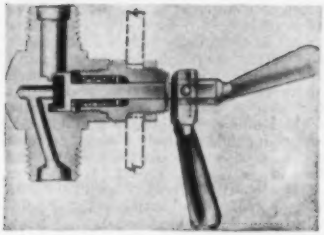
E. I. DU PONT DE NEMOURS & COMPANY (INC.)

PETROLEUM CHEMICALS DIVISION

Wilmington 98, Delaware

Laboratories: Wilmington, Del. · Chicago, Ill · Tulsa, Okla. · Houston, Texas · El Monte, Calif.

District Offices: Wilmington, Del. · Chicago, Ill. · Tulsa, Okla. · Houston, Texas · Los Angeles, Calif.



or for panel mounting. The bonnet is externally threaded and provided with a lock nut for mounting through a round opening in a panel board. The valve is sealed at the stem and at the junction of bonnet and body. Interchangeable colored plastic knobs provide easy identification for operating convenience. Pressure ratings range from vacuum service to 500 psig.

For a copy of Bulletin 16A, write Hoke Incorporated, Englewood, N. J., referring to PETROLEUM REFINER item **63.**

Hardfacing Alloys

Air Reduction Sales Company has available a new line of hardfacing alloys. Divided into three primary groups, ferrous alloys, cobalt base alloys, and tungsten carbide, 15 different alloys have been perfected. They were "especially developed to combat abrasion, impact, heat and corrosion."

For further information write Air Reduction Sales Company, 60 East 42nd Street, New York 17, referring to PETROLEUM REFINER item **64.**

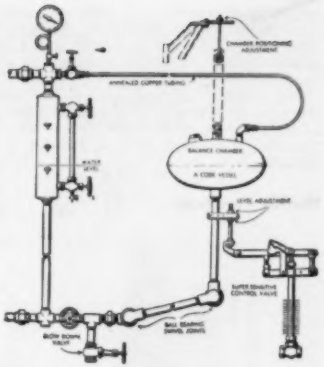
Coating and Primer

Niel-Coat P-110, a new type of rust preventative coating and primer incorporating a fixed percentage of phosphoric acid, has been developed and is available from Nielco Laboratories. It can be applied over rusted metal "to stop the rusting as well as to prevent further corrosion." Features claimed include "drying in two to four hours, leaving an elastic film that will expand and contract with the metal regardless of temperature extremes, keeping it from wrinkling or shrinking, being non-inflammable, non-explosive and non-toxic and not separating when in storage."

For further information write Nielco Laboratories, Detroit 19, Mich., referring to PETROLEUM REFINER item **65.**

Feed-Water Controller

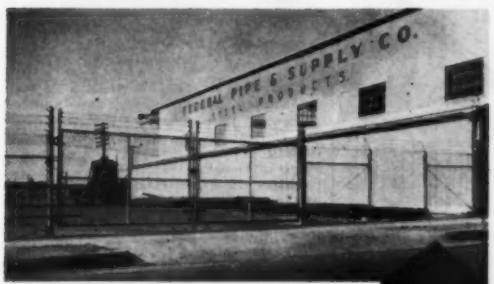
Weight-O-Water, the new boiler feed-water controller of J. A. Campbell Company, uses the weight of water as a force to motivate the feed-water valve. Since no heat is required to operate, "heat and cold have no effect on its performance." The controller uses an elypsoidal balance chamber hung on an engineered spring to permit its rising and lowering. The top and bottom of the chamber is connected with annealed copper tubing flexibly looped to the water column piping of the boiler at the top and bottom. Two swivel joints added at the bottom connection insure flexibility of chamber movement. If the water level rises ⅛ inch in the boiler, it rises ¼ inch in the chamber "because the movement of the chamber actuates a super-sensitive control valve which requires a force of less than ½ pound to actuate." The valve, opening and closing in response to the movement of the chamber, controls the amount of water fed to the boiler.



For further information write J. A. Campbell Company, 645 East Wardlow Road, Long Beach 7, Calif., referring to PETROLEUM REFINER item **66.**

Temperature Controller

A new low-cost combination motorized valve temperature controller is being introduced by Minneapolis-Honeywell Regulator Company. It is for on-off, two-position, floating or proportional control. A remote-bulb thermal system positions a motorized valve in response to temperature changes. The unit is available with temperature



SAFE...behind a
Realock Fence

Industrial property behind a Realock Fence is *safe*... because Realock Fence is a *constant* barrier to potential theft, arson, vandalism, and trespassing. And because it's constructed from hot galvanized steel, Realock Fence protection *lasts.*

See your local dealer for free estimates—expert erection service—special gate designing help.

AMONG OTHER CF&I PRODUCTS: Wickwire Rope, Clinton Welded Wire Fabric, Woven Wire Fence.

CF&I

The Colorado Fuel and Iron Corporation

General Offices: Denver, Colorado

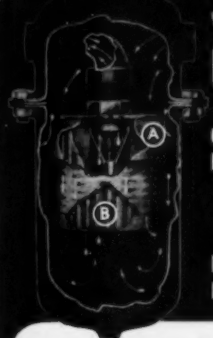
Pacific Coast Sales: The California Wire Cloth Corporation, Oakland, Calif.

STAYNEW GAS FILTERS

For Compressors, Gas-fueled Engines and Processes

DOUBLE ACTION

Principle Guarantees both CLEAN & DRY gas



Removes injurious pipe scale, rust, dust, dirt, water and other foreign matter from artificial or natural gas. Filter employs both mechanical separation and filtration. Deflector cup (A) directs gas to walls of housing, thence to base where heavier particles and liquids are deposited. Gas then rises thru exclusive Radial Fin Insert (B) where lighter particles are removed. Use steadily increasing in petroleum industry.

DOLLINGER CORPORATION

47 CENTRE PK., ROCHESTER 3, N. Y.

DOLLINGER STAYNEW FILTERS

COMPLETE DATA ON REQUEST

ranges between 50° and 700° F., and with different sizes and types of valves. The self-contained assembly includes valves, linkage, motor, transformer and temperature controller.

For further information write the Minneapolis-Honeywell Regulator Company, 2753 Fourth Avenue South, Minneapolis, Minn., referring to PETROLEUM REFINER, item **67.**

Muffle Furnaces

A new line of laboratory muffle furnaces designed for a complete over-all temperature range from 300 to 2000° F. is being offered by Cooley Electric Manufacturing Corporation for physical, chemical and industrial laboratory use in experimental testing, etc. This new line of furnaces is augmented by the Cooley Model ACL, and ACH recirculating air draw furnaces with built-in selective power modifier for temperature to 900 and 1200° F. A temperature uniformity of +5 to 0° F. is claimed through the use of the built-in selective power modifier, used in conjunction with an indicating controlling pyrometer. A power input of 4 kw. at 230 volts will bring the furnaces to operating temperature with unusual speed and the manufacturer says that any power input from 5 percent to full power may be obtained.

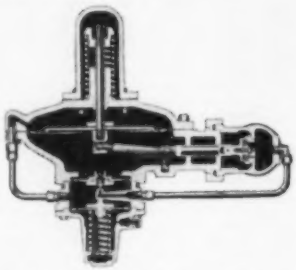
For detailed information write Cooley Electric Manufacturing Corporation, 38 South Shelby Street, Indianapolis 7, Ind., referring to PETROLEUM REFINER item **68.**

Germicide and Fungicide

Dowicide G, water-soluble sodium pentachlorophenate, germicide and fungicide for effective control of microorganisms in industry, is available from The Dow Chemical Company in hard pellets comparatively free from dust according to the company. Dow engineers have developed this purely physical change from flake to pellet to control the dust and facilitate handling the salt during its application to industrial and agricultural products. The small cylindrical pellets are compressed to one-fourth the volume of the original flake. The new pellets will be packed in 200 pound "Leverpak" fiber drums and will be marked "pellets" to distinguish them from the flake.

For further information write The Dow Chemical Company, Midland, Mich., referring to PETROLEUM REFINER item **69.**

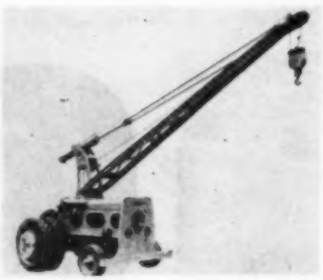
Gas Pressure Regulator



Fisher Governor Company has in production its new Fisher type 99 multipurpose gas pressure regulator. Available in two inch screwed pipe thread connections only, it is suitable for inlet pressures up to 150 pounds and reduced pressures of four ounces to 50 pounds. The regulator range runs from 0 up to 143,000 cubic feet per hour. Due to its special internal construction and pilot construction, the manufacturer claims that it is able to manitain a constant reduced pressure on all flows from 0 up to the maximum limit.

For a copy of Bulletin P-99 write Fisher Governor Company, Marshalltown, Iowa, referring to PETROLEUM REFINER item **70.**

Crane



Mounted on a Model UTI, Minneapolis-Moline tractor, the Clyde Handi-Crane of Clyde Iron Works, Inc., has a lifting capacity of four tons and revolves 320 degrees. Featured are "easy steering due to its special steering gear with roller bearing knuckles and the all-steel, welded boom, raised and lowered by means of a hydraulic cylinder." Both the cylinder and boom are mounted on a turntable that rides between two rows of large-diameter, steel balls. The operator's seat is offset and all controls are grouped within reach. In addition to handling loads with a hook, magnet or bucket, a drawbar is included for towing service.

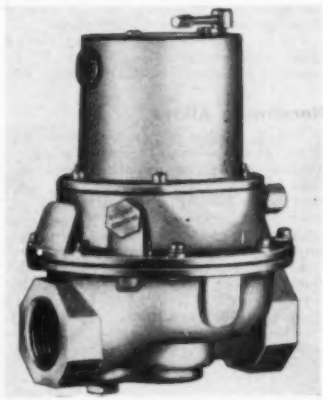
Bulletin MP-40 gives details and may be had by writing Clyde Iron Works, Inc., Duluth, Minn., referring to PETROLEUM REFINER item **71.**

Gas Safety Guard

Flashing a red signal light when a dangerous concentration of combustible gas is present in the surrounding air, Explosilite, made by Mine Safety Appliances Company, is claimed to serve as a safety guard for workers in utility vaults and manholes and in maintenance and repair operations in storage tanks and other confined spaces. It has been approved by the U. S. Bureau of Mines for use in atmospheres contaminated with methane. Completely portable and self-contained, Explosilite may be preset for a specific concentration of natural gas or petroleum vapors. It operates automatically. Current is supplied by an Edison nickel-iron battery. The Explosilite is called tamper-proof.

For a copy of Bulletin DT-4 write Mine Safety Appliances Company, Braddock, Thomas and Meade Streets, Pittsburgh 8, referring to PETROLEUM REFINER item **72.**

Diaphragm Gas Valve



Designed for reliable control of natural, manufactured, mixed and liquefied petroleum gases to space and unit heaters, central, floor and wall furnaces and boilers, the B-50 electric diaphragm gas valve of General Controls Company has packless construction and all body parts are of die formed aluminum. The valve is available in sizes from ⅜-inch to 1¼-inch pipe size. According to the company, the valve is silent, has no packing glands or bellows and has a five watt current consumption. For low or line voltage applications, the standard and manual opening models are available with or without electric trip.

For further information write General Controls Company, 801 Allen Avenue, Glendale 1, Calif., referring to PETROLEUM REFINER item **73.**

Ultracentrifuges

Details of the new Spinco ultracentrifuge are presented in Bulletin 1S1148U8 by Specialized Instruments Corporation. Adaptable to the purification and particle-size determination of proteins, viruses, polymers and other such colloids, the machine has its driving mechanism, rotor, light source, controls and pumps designed to fit into a single laboratory-type enclosure. The speed and camera-control unit, which can maintain 0.1 percent accuracy of desired speed, is described and illustrated, as well as the rotors and safety devices incorporated into the unit. In connection with a dis-

cussion of the Philpott-Swensson type optical system a diagram showing the parts and their location in the unit is included.

For a copy of the bulletin write Specialized Instruments Corporation, 1154 O'Neill Avenue, Belmont, Calif., referring to PETROLEUM REFINER item **74.**

Verticlosed Pump Motor

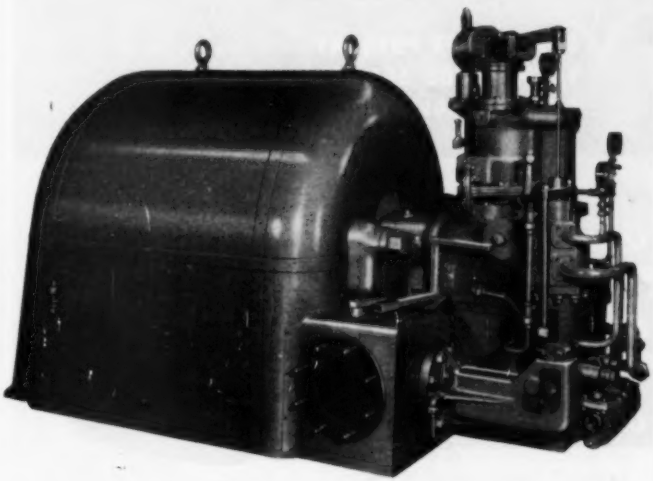
The new Verticlosed Streamway motor of U. S. Electrical Motors, Inc. has a downdraft ventilation system which is claimed prevents reentry of expelled hot air into the motor. The universal, interchangeable ring base, permits use of various sizes of motors so that the horsepower capacity of the motor can be increased or decreased as necessary. A water proof housing protects the interior from exposure, asbestos insulation prevents carbonization and normalized castings insure precision accuracy, according to the manufacturer. The lubriflush lubrication system provides a "thorough flushing of all devitalized grease by forcing clean grease through each bearing and a gravity-fed oil flow insures the correct oil supply." Other features of the pump include a solid cast aluminum rotor and reverse protection clutch.

For a copy of Bulletin F-1454 write U. S. Electrical Motors, Inc., 200 East Slauson Avenue, Los Angeles 54, Calif, referring to PETROLEUM REFINER item **75.**

Pipe Cutting Machine

The 662 "Cut Master" of The Oster Manufacturing Company is designed for cutting small or large quantities of pipe within the range of ¼ to 2 inches inclusive. The ½ hp. 10,000 rpm. universal motor has variable speed and a geared head for light socket operation. Gear ratio is 29.25 to 1. The motor, idler shaft and cutter shaft are mounted as a unit on a plate hinged to the base casting. The operator's work is reduced to a min-

MURRAY
TYPE UV



MULTI-STAGE
STEAM TURBINES

Simplicity and reliability characterize the Murray Type UV Turbine. Available in from two to ten pressure stages on two basic pitch diameters. The Type UV can be supplied in capacities from 100 to 4000 HP, condensing or non-condensing. It can be used for mechanical drives or for smaller generator drives.

Murray Type UV is durably built for dependable performance. Horizontally split case construction to suit operating conditions. Blades are stainless steel, shafts of alloy steel. The assembled rotors are dynamically balanced. Governors are provided to suit specific job requirements.

Let our engineers cooperate in smoothing out your power problems.

WRITE FOR BULLETIN T-122

MURRAY IRON WORKS COMPANY

BURLINGTON, IOWA

BUILDERS OF STEAM POWER EQUIPMENT FOR THREE QUARTERS OF A CENTURY

Okadee
VALVES
CHECK YOUR PRESENT VALVE NEEDS AGAINST OKADEE'S ADVANTAGES:
OK'd
OK'd
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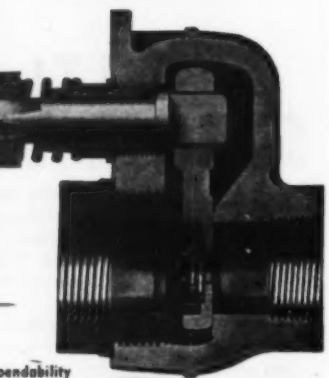
What do you expect from your valves? Dependability and economy head the list for most operators. And that's why so many have OK'D OKADEE VALVES for service after service. OKADEE'S solid, one-piece body . . . straight full opening . . . minimum pressure drop . . . self-polishing, full floating and rotating discs held tight by pressure . . . mean dependability with longer life and lower maintenance costs. OKADEE Valves are available in a wide range of sizes, flanged or screwed types of lever, rack and pinion or wheel operation. OKADEE VALVES are distributed by WECO. Let us send you complete information!
WELL EQUIPMENT MFG. CORP.
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imum by a feed screw mechanism. Rollers supporting the pipe to be cut are mounted on needle bearings to minimize friction, permitting the pipe to turn freely. Rollers are grooved to prevent breakage of the cutter wheel, which is ground to reduce burr on the pipe to a minimum. The remaining burr is easily removed by chamfer on the dies. It weighs only 225 pounds.

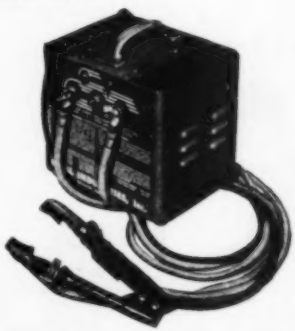
For further information write The Oster Manufacturing Company, 2057 East 61st Street, Cleveland 3, Ohio, referring to PETROLEUM REFINER item **76.**

Dial Thermometer

Production of a new, heavy duty, dial type thermometer has been announced by Qualitrol Corporation. Pointer indications may be read from almost any position because the concave dials are curved at the indicating graduations. There is a choice of seven temperature ranges from minus 90 to 1000° F. Dial sizes are 2, 3 and 5 inches. The connecting nut and stainless steel stem will withstand pressures in excess of 2500 psi. Cases are hermetically sealed and the pointers show no oscillation under extreme vibration conditions. Degree of accuracy is demonstrated by a test of more than 500,000 full scale heating and cooling cycles which showed no change in calibration.

For a copy of Bulletin 100 write Qualitrol Corporation, East Rochester, N. Y., referring to PETROLEUM REFINER item **77.**

Soldering Tool



Ideal Industries, Inc. has available a new light duty Thermo-Grip soldering set that operates on the resistance heating principle. This portable unit does the job quicker, safer and easier, eliminating fire hazards and discolored work, according to the manufacturer. A complete set of tools includes a plier attachment for sweating and unsweating copper tubing, a fork attachment with two 3-inch electrodes for reaching into restricted places and a pencil attachment with one 3-inch carbon electrode for spot soldering and light seam soldering. In the 450-watt unit there are two soldering heats, Hi-5.3 volts and Lo-4.2 volts.

For further information write Ideal Industries, Inc., Sycamore, Ill., referring to PETROLEUM REFINER item **78.**

Flow Meters

High accuracy that is attained in the Hays-Cochrane friction free electric type flow meters of The Hays Corporation is discussed in Bulletin 48-800. Photographs, diagrams and cross sections, etc., are included. Said to be adaptable to variable conditions through transmitters of various capacities, the flow meters also "have low maintenance and operating costs." Gas or air flow recorders, boiler efficiency meter, linameter, liquid level meters and primary elements also are presented.

Hays-Cochrane high torque mechanical flow meters are discussed in Bulletin 47-801. The fundamental principles which produce high torque and accuracy are outlined and application of these principles to its high torque flow meter is illustrated. Specifications, diagrams and descriptive material are also included about the Hays-Cochrane integrator and spaced charts.

For copies of the bulletins write The Hays Corporation, Michigan City, Ind., referring to PETROLEUM REFINER item **79.**

Arc Welding

In Bulletin 466, issued by The Lincoln Electric Company, the factors which the company consider important to the success of hard surfacing by the arc welding process are discussed. Points include "service required, service conditions, part to be surfaced, dimensions and finish required." A "Guide for Electrode Selection" and illustrative applications showing materials and procedures employed for particular problems are also given.

For a copy of the bulletin write The Lincoln Electric Company, Cleveland 1, Ohio, referring to PETROLEUM REFINER item **80.**

Electric Desalting

Complete information on the firm's electric desalting method and equipment is offered by Petroleum Rectifying Company in its latest bulletin. The dangers of salt in the crude charge and how to determine the amount are set forth as are advantages of their process and solution of field problems. Details of the electric desalting process also are described; charts of salt content and actual operating data as well as photographs of equipment used in the process are included.

For a copy of the bulletin write Petroleum Rectifying Company, 5515 Telegraph Road, Los Angeles 22, California, referring to PETROLEUM REFINER item **81.**

Corrosion in Boilers

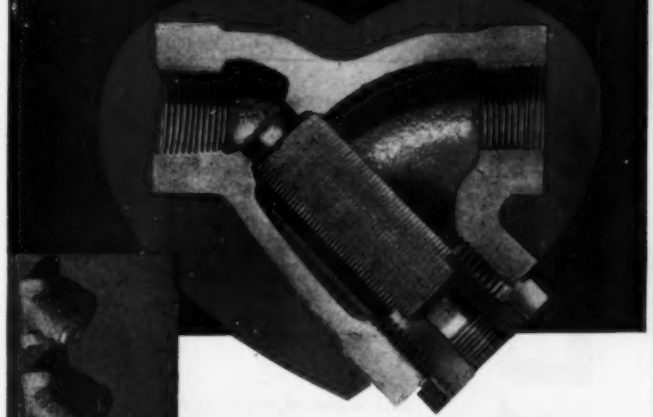
The cause and prevention of corrosion in boiler systems is discussed in W. H. and L. D. Betz's Technical Paper 111. The corrosive effects of oxygen, carbon dioxide, ammonia, hydrogen sulfide, acidity and physical factors are evaluated. Illustrations, graphs and tables are included.

For a copy of the paper write W. H. and L. D. Betz, Philadelphia 24, referring to PETROLEUM REFINER item **82.**

Electrical News

A new publication, "The Cannon Electric Cannonade," to be published bimonthly, will cover background information and current news about Cannon Electric Development Company, its sales and engineering department, production

The SCREEN of the YARWAY STRAINER



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personnel, representatives and distributors. Latest developments in the connector and electrical specialty fields will be featured and changes in materials, construction, identification of standard lines as well as new developments will be presented.

For a copy of the publication write Editor, Cannonade, Cannon Electric Development Company, 3209 Humboldt Street, Los Angeles 31, referring to PETROLEUM REFINER item **83.**

Hexadecene

Houdry Process Corporation has available, in research quantities, hexadecene, an olefin raw material which has many possibilities in organic synthesis, being utilized in several olefin reactions. Physical properties are boiling point, 242° C.; pour point, less than minus 50° C.; flash point, 90° C.; viscosity at 38° C., 3.57 centistokes; at 54° C., 2.57 centistokes; at 99° C., 1.33 centistokes.

For further information write Houdry Process Corporation, 225 South 15th Street, Philadelphia 2, referring to PETROLEUM REFINER item **84.**

Self-Propelled Cranes

The Thew Shovel Company has released a new bulletin, "Self-Propelled Cranes," illustrating various applications of self-propelled cranes for industrial material handling and construction operations. Lorain self-propelled cranes are single-engine, one-man operated cranes, with four speeds in either direction. They have speeds up to seven miles per hour. The self-propelled models, which have air brakes, full air-power steering maneuverability and adaptability to many materials.

For a copy of the bulletin write The Thew Shovel Company, Lorain, Ohio, referring to PETROLEUM REFINER, item **85.**

Turbo Pumps

The J. S. Coffin, Jr., Company has available Bulletin "S" describing its types CC and CG turbo pumps. These two models are designed for steam pressures to 850 psi., back pressures to 200 psi., pump capacities to 500 gallons per minute, discharge pressures to 1100 psi., and liquid temperatures to 300 degrees Fahrenheit. Cross-section illustrations of the pump, running gear and governor detail and pictures of other pumps of the company are included in the bulletin.

For a copy of the bulletin write The J. S. Coffin, Jr., Company, 326 South Dean Street, Englewood, N. J., referring to PETROLEUM REFINER item **86.**

Thermocouple and Pyrometer

A new thermocouple and pyrometer accessories bulletin has been published by The Bristol Company. A technical section, described as the "Users" Manual," contains engineering handbook data on factors affecting thermocouple life, corrosion and poisoning, thermocouple reproducibility, thermocouple insulation and how to select the right thermocouple and protection tube for every application. The catalog section, described as the "Buyers' Guide," is indexed and illustrated with line drawings and photographs and includes the company's complete line of thermocouples, thermocouple wire, protection tubes, insulators, extension wire and accessories.

Tables of calibration data for the commonly-used base-metal and rare-metal thermocouples are given also.

For a copy of Bulletin P1238 write The Bristol Company, Waterbury 91, Conn., referring to PETROLEUM REFINER item **87.**

Tubeflo Section

Engineers who have difficulty with heat exchangers that become clogged from dirty or corrosive fluids will be interested in Bulletin 1622 describing the Type CW tubeflo section which has just been published by The Griscom-Russell Company. The bulletin explains how heavy viscous or sediment-bearing liquids are carried completely through this unit without fouling. Several instances in which G-R tubeflo sections are continuing to maintain rated capacity on services where conventional types of heat exchangers caused trouble are also given.

For a copy of the bulletin write The Griscom-Russell Company, 285 Madison Avenue, New York 17, referring to PETROLEUM REFINER item **88.**

Packaged Gas Burners

Bulletin 7C describes the Pow-R-Semblies, packaged industrial gas burner assemblies complete with pressure blowers, of Bryant Heater Company. Capacities, specifications, dimensions and alternative assemblies are given for the units, which are applicable to boilers, air heaters, dryers, kilns, ovens and other equipment to which open burners with controlled flames are suitable. Sizes range from 400,000 to 6,600,000 Btu. per hour of output.

For a copy of the bulletin write Bryant Heater Company, Industrial Division, 1020 London Road, Cleveland 10, Ohio, referring to PETROLEUM REFINER item **89.**

Cooling Tower

The Marley Company, Inc., has prepared a series of question and answer type monthly mail reports, available on request, entitled "What's Your Cooling Tower I. Q.?" The first of the series deals with water distribution, the second with air movement, the third with facts and figures and similar problems.

To receive these reports write The Marley Company, Inc., 3001 Fairfax Road, Kansas City, Kas., referring to PETROLEUM REFINER item **90.**

Surface Chemistry

"Surface Activity and Detergency," a new publication from Foster D. Snell, Inc., consulting chemists and engineers, covers new services being offered due to recent developments in the field of surface chemistry.

For a copy of the booklet write Foster D. Snell, Inc., 29 West 15th Street, New York 11, referring to PETROLEUM REFINER item **91.**

Flexible Tubing

Pennsylvania Flexible Metallic Tubing Company's new bulletin, "Penflex Flexineering," illustrates and describes its line of flexible metal tubing, applications, etc.

For copies of the bulletin write Pennsylvania Flexible Metallic Tubing Company, 72nd Street and Powers Lane, Philadelphia 42, referring to PETROLEUM REFINER item **92.**

Read the latest on

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RECOVERY

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and how to trap them is the subject of Buell's 32-page catalog on dust recovery. It tells you why only Buell offers you a *fractional* efficiency guarantee. It's the only kind of guarantee that *accurately* and *reliably* predicts dust collector performance. The performance figures are often surprisingly high, for the Buell system has the patented van Tongeren 'shave-off'. It's an efficiency 'plus' found only in Buell's large diameter, non-clogging cyclones. Don't miss this factual booklet on planning dust recovery installations. Write today to the Buell Engineering Company, 6 Cedar Street, Suite 5000, New York 5, N. Y.

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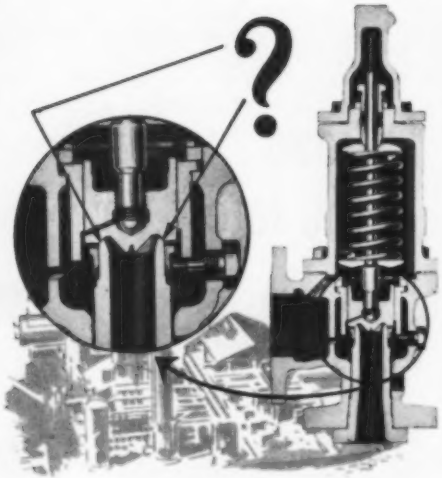

Why the *Outside* Bevel Seat?

The Outside Bevel Seat and Floating Guide construction supplied only in CONSOLIDATED Safety Relief Valves provides the *flexibility* which eliminates leakage despite bolting strains and discharge piping stresses.

The outside bevel seat permits movement of the disc on a radial seating surface and assures tightness in all positions within the deflection range.

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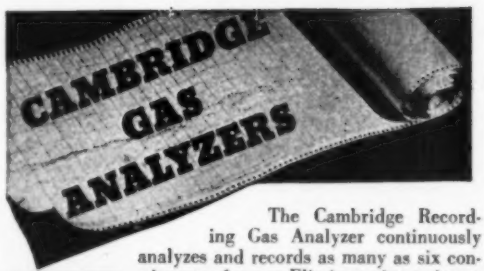

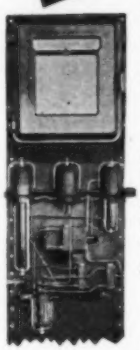

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About EQUIPMENT and SERVICE Suppliers

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Ardun Company Is Appointed Tube-Turn Representative

Ardun Company, Tulsa, has been appointed a distributor of Tube-Turn, Inc., welding fittings and flanges. The firm, which has its offices and warehouse at 317 South Detroit Avenue, Tulsa, is a partnership formed by H. W. Arduser and Robert H. Duenner, Jr., who have announced they will maintain "one of the West's largest stocks of Tube-Turn welding fittings and flanges." The firm also is handling the industrial products of other nationally recognized manufacturers.

Arduser obtained his bachelor of science degree in mechanical engineering from Purdue in 1931, and began his career with The Pure Oil Company in 1932, becoming chief production engineer of the eastern producing division. He founded Arduser and Company, which specializes in the sale and servicing of oil and refinery equipment.

Duenner attended Lehigh University, where he obtained his bachelor of science degree in industrial engineering in 1939 and did postgraduate work in metallurgy, mechanical engineering and finance. In 1939, he joined Bethlehem Steel Corporation and later was assigned to the firm's sales staff in Tulsa. He served as an ensign in the Navy from 1944 to 1946, then organized the Robert Duenner and Company, manufacturers' representatives.

D. H. Greenwood Retained By Falcon Products, Inc.

D. H. Greenwood, associated with the oil well supply business for the past 30 years and inventor of numerous valves and devices used in drilling, production and refining equipment, has been retained by Falcon Products, Inc., Pomona, Calif., to supervise sales, installation and application of Falcon products.

A member of the California Natural Gasoline Association and Southern California Meter Association, he has been in the oil well supply business for himself since 1923. Prior to that time he spent four years as corporation salesman with Associated Supply Company.

T. L. B. Lyster Retires; Hooker Names E. K. Newton

T. L. B. Lyster, chief engineer of the Hooker Electrochemical Company from 1914 to 1917 and from 1937 through 1948, has retired. Lyster, associated with Hooker in various capacities since 1907 as construction engineer, director of development, consulting engineer and chief engineer, from 1922 to 1932, devoted much of his time to pulp and paper industry service and engineering. He will continue as consulting engineer for the company.

E. K. Newton, who has been with Hooker as an engineer since 1910 and has held various engineering positions with the company, has been appointed chief engineer.

Aldrich Pump Names Agent

The Aldrich Pump Company, Allentown, Pa., has named Jesse W. Eskins Company as its representative for the Detroit area, effective January 1. The company is located at 3105 East Grand Boulevard, Detroit 2.

George Stroup Joins Nelson As Tulsa Sales Engineer

George W. Stroup, Jr., has joined the sales department of Nelson Electric Manufacturing Company, Tulsa. He will represent the company as a sales engineer in the Tulsa territory.

Stroup

Stroup acquired previous sales and engineering experience while employed by Roach Equipment Manufacturing Company and Buda Engine Sales and Service, Inc.

Before serving in the Naval Air Force, he studied mechanical engineering at Oklahoma A. & M. College. Receiving his wings in 1943, Stroup was assigned to the USS Midway. He was released from active duty in 1946.

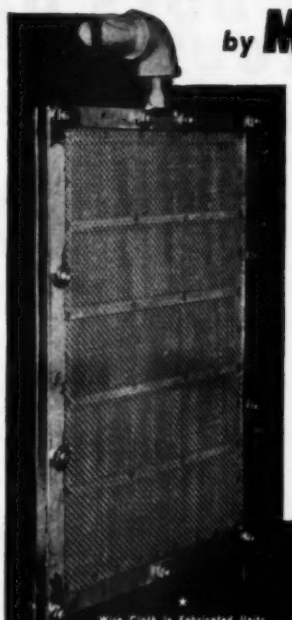
Northern Equipment Shifts Top Engineering Personnel

Northern Equipment Company, Erie, Pa., has made personnel changes as follows:

Harold A. Schlieder, resigned as chief engineer to open own office as sales and service representative at 520 Robineau Road, Syracuse, N. Y.

Francis W. Bunting, assistant chief engineer, named chief engineer in charge of all sales and service engineering. A graduate of Drexel Institute of Tech-

FILTER CLOTH UNITS by MULTI-METAL



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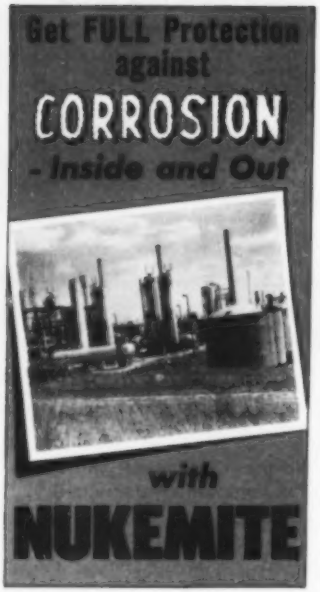

A protective coating of NUKEMITE will give long-lasting protection inside tanks and at other vulnerable points, against sour crude and other corroding agents. An inert solution of the vinyl co-polymer type, NUKEMITE forms a tough protective coat, yet is easily applied like paint, by brush or spray method.

NUKEMITE 35

Strongly bonded to metal by superior adhesion of vinyl co-polymer primer. Flexible, durable and tough — unaffected by strong alkalies, sour crude and Aliphatic Hydrocarbon solvents. No special skill in application needed.

NUKEMITE 24

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nology, he is a member of the American Society of Mechanical Engineers and the National Society of Professional Engineers. He came to Northern in 1935.

Harry H. Weining placed in charge of all production engineering in addition to his duties as director of research. He is a graduate of Pennsylvania State College, a member of Tau Beta Pi and the National Society of Professional Engineers. He has been with the company since 1925.

Floyd Snodgrass Appointed Manager Nordstrom Valve

Floyd V. Snodgrass has been named general manager of the Oakland, Calif., plant of Nordstrom Valve division of Rockwell Manufacturing Company.

Snodgrass

Starting with the company in 1935 as a machinist, he has advanced through the organization to plant manager, assistant general manager and his present position.

In February, 1948, Snodgrass was named "Man of the Month" by two West Coast metal working publications. He is past chairman of the Golden Gate Chapter of the American Society of Tool Engineers and a member of the East Bay Policy Committee of the California Metal Trades Association.

J. W. L. Stone Named Manager Peerless Nebraska District

J. W. L. Stone has been appointed district manager of a newly formed sales district of Peerless Pump Division of Food Machinery and Chemical Corporation, with headquarters located at 4330 Leavenworth Street, Omaha, Neb.

Stone

Formerly a field engineer for the Peerless division in the southwest district, Stone, as district manager, will now supervise the sales of both the Peerless horizontal and vertical lines and other pumps of the company's manufacture. His territory will include North and South Dakota, Montana, Minnesota, Nebraska, Kansas, Colorado and portions of Wyoming, Missouri, Wisconsin and Iowa.

De Laval Steam Turbine Makes Executive Changes

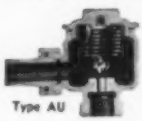
De Laval Steam Turbine Company, Trenton, N. J., in January made the following executive changes:

Henry W. Johnson is retiring as vice president in charge of manufacturing, but will continue as director and a member of the executive committee.

C. Richard Waller has been named vice president and director for engineer-

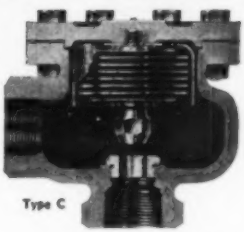
DOES DIRT PLUG YOUR STEAM TRAPS?

Larger, At-Bottom Valve Keeps Nicholson Traps Clean



Type AU

Type AHV



Type C

Valve orifices of Nicholson steam traps are 2 to 6 times larger than in average traps, minimizing chances of plugging. And, valves being at the bottom, dirt drops out by gravity. This ability to self-clean is one of the features resulting in the unequalled discharge capacity of Nicholson traps. 5 types for every industrial application; size ¼" to 2"; press. to 225 lbs. Test trap gladly sent. BULLETIN 1047.

HIGH-PRESSURE FLOATS — Stainless, monel, steel or plated steel. Welded. In all sizes and shapes; for operating mechanisms and as tanks or vessels. 2-day delivery. BULLETIN 348.

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ing and H. G. Bauer has been elected vice president and executive engineer. J. P. Stewart, former manager of the commercial sales division, has become a vice president.

W. A. Reynolds assumes responsibility for the development and merchandising of new small products in addition to his position as manager of the pump and worm gear divisions.

W. A. Neumann, Jr., has been appointed controller.

Clark Appoints Dick Jenkins To Technical Service Group

Clark Brothers, Olean, N. Y., has appointed Dick Jenkins to its technical service department in Los Angeles. Joining the company in 1948, following his graduation from Yale University, he previously was engaged in research at the main office of the company.

Jenkins

A member of the Torch Senior Honor Society at Yale, Jenkins was graduated from the Yale Sheffield School of Engineering. He was a football and track man while in college.

Jenkins spent six months in the Army specialized training program for mechanical engineers, before joining the 7th Army in the European theater of war.

Frank Whelan to Supervise Worthington Pump Division

The sale of welding positions and turning rolls manufactured at the Dunellen Works of Worthington Pump and Machinery Corporation will be supervised by Frank J. Whelan, vice president. He will be located at the company's executive offices at Harrison, N. J.

Whelan

He will also continue to supervise the sale of Worthington's standard pumps, compressors and mechanical power transmission equipment sold through industrial and oil field distributors, as well as sales to original equipment manufacturers.

F. J. Connolly will remain as manager of the welding positioner and turning roll sales division and A. B. Kime will continue as eastern regional supervisor. P. J. Patton, Jr., will remain as central regional supervisor.

T. R. Weichel Named Okonite Mining Electrical Engineer

Thomas R. Weichel, formerly of the United States Bureau of Mines, is associated with the sales department of Hazard Insulated Wire Works division of The Okonite Company, Wilkes-Barre, Pa., as mining electrical engineer. He will serve as technical and sales con-

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FOR HOODED CHLORINE TANKS

Typical of the versatility of Lenape Press Forged products is this 18" manway of silicon killed steel with special 37" O.D. flange. In addition to standard bolting, an outer circle of holes has been tapped to attach the hood or dome.

Lenape seamless necks, nozzles, and other pressure vessel fittings are produced in a complete range of sizes to code or private specifications in carbon steel, alloy steels, stainless, and other alloys.

Send blue prints and/or specifications for recommendation and prices. Our engineering department will be glad to discuss particular problems without obligation.

Quotations will be given our immediate attention — Bulletin 4-48 and current price schedule M-47 will be sent upon request.

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Here are the "PRINCO" Thermometers for those really TOUGH service conditions. Cases are extra heavy castings, specially designed for maximum strength. Frames and cases are BOLTED together. Glasses are extra heavy plate to withstand shock and vibration. Cases completely sealed against fumes and moisture. Built-in dehydrator prevents fogging or condensation. Extra protection for mercury tubes assures maximum service life.

Available in all standard case angles and temperature ranges, or to your specification. RED READING MERCURY or Canary-backed tubing optional. Wide selection of "Princo" Separable Sockets in a variety of materials. Write for full information and prices. Ask for Bulletin "E".

NEW! PRINCO "Easy-Setting" DIAL THERMOMETERS
5 Standard Scale Ranges
"Easy-Access" Cases for Quick Setting
Simplified Dial and Pointer Adjustment
Rugged, Accurate, Bimetallic Unit
Write for prices and additional information.

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THERMOMETER & INSTRUMENT COMPANY
PRECISION INSTRUMENTS PRINCO FOR INDUSTRY
In Canada: PEACOCK BROTHERS Limited
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MAINTENANCE CREW HANDS OFF!

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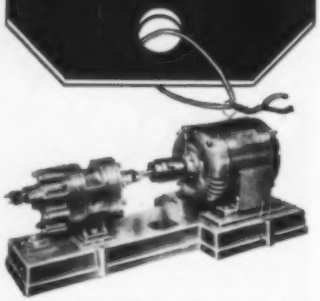
SIER-BATH ROTARY PUMP



Sier-Bath Screw Pumps and Gearex Pumps are designed to do a job—and keep doing it. The manufacturer has a full appreciation of the high cost of interrupting the operation of a line to permit pump repairs. On the Internal Gear-type Screw Pump, for example, the gland is the only point of attention and as this is on the suction side, it is almost negligible. It is not unusual for the packing to last two years without repacking. The pressure on the gland is so slight that it is possible to add a new ring of packing without shutting down the unit. Send for information.

ALSO MAKERS OF SIER-BATH PRECISION GEARS

FOUNDED 1905 MEMBER A.G.M.A.

Sier-Bath GEAR and PUMP CO., Inc.

9249 HUDSON BLVD NORTH BERGEN, N J

sultant for all types of electrical mining and portable cables, working with the technical and production departments, as well as sales, in developing cable designs to aid in mine electrification.

A graduate of Pennsylvania State College with degrees of mining engineer and electrical engineer, Weichel has served as mining engineer for the Bureau of Mines for the past six years. He also has been active on committees of the American Institute of Electrical Engineers, the American Standards Association and the American Mining Congress.

Airetool Opens Three Branches; J. M. Brown Heads Tulsa Post

During the past year, three new branch offices were opened by Airetool Manufacturing Company, Springfield, Ohio. First of the new offices was opened in Philadelphia. The second is located in Baton Rouge, La., while the third and most recent was opened in Tulsa.

Brown

James M. Brown, company representative who had been in charge of the Baton Rouge office since it was opened in May, 1947, was given the Tulsa assignment when that office was started late in 1948. Coming to the company in May, 1946, he acted as company representative in Ohio and adjoining states for a year before going to Baton Rouge. He was succeeded in that district by M. E. Segraves.

As part of his present assignment as manager of the new Tulsa branch, Brown will be giving Airetool service to customers in Oklahoma, north and west Texas and eastern New Mexico. He will also be available for service calls in Kansas.

The Philadelphia office remains in charge of Herbert Russell, with headquarters in the Bourse Building.

Black, Sivalls and Bryson Name World Export Manager

General Harlan L. Mumma, U. S. A. retired, has been appointed world export manager of Black, Sivalls and Bryson, Inc., with headquarters at 30 Rockefeller Plaza, New York. He recently returned from a tour of industrial centers in several South American countries.

Mumma

Retired from the army in April, 1948, after 36 years of active service, General Mumma was assigned to the New York Port of Embarkation as assistant superintendent of the Army Transport Service from 1938 until January, 1941. At that time he was transferred to the West Coast as quartermaster of the Third Army Corps with headquarters at Monterrey, Calif. In June, 1941 he went to the Caribbean where he became chief of supply and

CONTROL

Scale and Corrosion In Water Cooled Equipment

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Newly Perfected

Water Conditioning Chemicals

Recently developed applications of the newer colloids and surface-active agents in Wright Chemicals for the petroleum industry result in *improved* water conditioning—*positive* scale and corrosion control. Wright Chemicals contain 100% soluble, available chemicals—no waste or inert matter—insuring increased operating efficiency and reduced cost.

Cooling Towers . . .

Down time and replacement costs are materially reduced by effective scale and corrosion control with Wright Chemicals.

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Heat transfer surfaces are kept free of scale and corrosion. Result? Greater efficiency.

Wright improved chemicals are the result of intensive study and research by men with years of experience in the development, production, application and control of water-conditioning chemicals.

Wright has no one cure-all to solve all problems. Each receives individual treatment. The Wright field engineer, who will call on you upon request, will obtain all necessary information and samples for examination in the modern Wright laboratory. Analyses are interpreted in view of supplemental information received, and recommendations made in the form of a proposal. Clients are provided with regular laboratory service as a periodic check upon conditions.

There is a Wright Field Engineer near you, anxious to help solve your scale and corrosion problems. No obligation.

Wright CHEMICALS

WRIGHT CHEMICAL CORPORATION

Specializing in Water Conditioning

GENERAL OFFICE AND LABORATORIES

615 West Lake Street Chicago 6, Ill.

Offices in Principal Cities

chief of transportation of the Panama Canal department.

Earl Ruth has been appointed consulting engineer to work with General Mumma. He was formerly sales engineer in the Kansas City offices of the company.

Fairbanks, Morse Make Series Of Promotions and Changes

A series of promotions and changes in the sales division of Fairbanks, Morse and Company, Chicago, were recently made.

O. O. Lewis, former assistant sales manager, promoted to sales manager.

Harry L. Hilleary, for 17 years manager of the firm's St. Louis branch, transferred to Chicago headquarters as assistant sales manager.

L. A. Weom, manager of the pump division, transferred to St. Louis to become branch house manager, succeeding Hilleary.

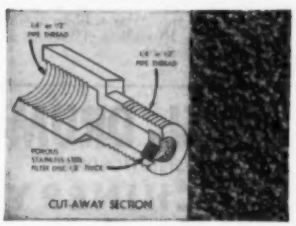
Donald T. Johnstone, assistant manager of the pump division, to succeed Weom as manager of the division, Chicago.

Louis Ward Joins Spencer

Louis L. Ward has joined the chemical sales staff of Spencer Chemical Company, Kansas City, Mo. and will serve as a salesman.

Studying at the University of Kansas and Leland Stanford Junior University, he was a member of the armed forces during the recent war. Prior to this appointment Ward was employed by Sinclair Coal Company.

New and Exclusive!



Equipoise POROUS Stainless Steel PRESSURE SNUBBERS

These new snubbers utilize a porous stainless steel disk as the primary element to eliminate pulsations. They can be used to protect all types of pressure sensitive instruments. Namely, pressure gauges; pressure indicating and recording controllers; diaphragm type differential meters; U-tube manometers; differential flow meters; pump governors; and diaphragm regulators. They also can be used as filters or as flow meters on small flows.

The porous disk is made in several standard Grades. Special grades made to suit application.

Grade "G" Air, gases, Butane, gasoline.
Grade "E" Water, kerosene, light oils, etc.
Grade "D" Oil, etc., having viscosity over 300 SSU.

Write for literature — Dept. WL

EQUIPOISE CONTROLS
INCORPORATED
100 STEVENS AVE., MT. VERNON, N. Y.

Motheral Is Named to Head Gulf Publishing Eastern Sales

Roger Motheral, Central district manager at Cleveland, has been appointed vice president in charge of Eastern sales for the Gulf Publishing Company, Houston, publishers of *World Oil*, PETROLEUM REFINER and oil industry composite catalogs. He will have offices in New York.

Motheral

With Gulf since July, 1946, Motheral previously had been Eastern district manager of the *Petroleum Engineer* for ten years. For several years he worked in Texas and California oil fields, and put in two years of service in foreign fields.

Bill Westfall, now with Gulf Publishing Company in Houston, succeeds Motheral as manager of the central district of Cleveland.

Booth to Head Brown and Root Public Relations Department

Brown Booth, public director with Tennessee Gas Transmission Company for 3½ years, has resigned to take charge of public relations and advertising for Brown & Root, Inc., Houston. Before joining T-G-T, Booth was managing editor of the Austin (Texas) *Statesman*, and prior to that was editor of the McAllen *Daily Press*. Booth is a 1935 graduate of the University of Texas Department of Journalism.

Booth

He has been succeeded at T-G-T by Conrad Collier, formerly publicity manager for the Houston Chamber of Commerce.

F. H. Meyers Heads Republic San Francisco Branch Office

Republic Flow Meters Company has opened a new branch office in San Francisco with Frederick H. Meyers appointed district manager.

Before Meyers joined Republic 12 years ago he was graduated from an Eastern engineering college and had been an engineer at a large eastern public utility station for 17 years. He engineered many large control installations during his nine years in Republic's engineering department in Chicago and he just completed three years as district manager at Cincinnati, Ohio.

Brown Instruments Makes Four Changes in Sales Personnel

Brown Instruments division of Minneapolis-Honeywell Regulator Company has made the following changes in its personnel:

Warren W. Matlack named industrial manager of the New York City branch, succeeding O. B. Wilson, regional sales

industrial OIL AND GAS BURNING EQUIPMENT

- Mechanical Atomizing Oil Burners
- Steam Atomizing Oil Burners
- Refractory Burner and Muffle Blocks
- Industrial Gas Burners
- Low Air Pressure Oil Burners
- Fuel Oil Pump Sets
- Valves, Strainers, Furnace Windows
- Tandem Block Combustion Units
- Combination Gas and Oil Burners

Detailed information gladly sent you upon request.

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FERTILIZER FROM NATURAL GAS

We Design
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FACILITIES FOR PRODUCTION OF AMMONIA DERIVATIVES FOR

HIGH NITROGEN CONTENT FERTILIZERS

Silas Mason Company

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BOX 1162, SHREVEPORT, LOUISIANA

QUICK REPAIRS ON
CONDENSERS
and
HEAT EXCHANGERS

If you need condenser or heat exchanger repairs *in a hurry* call us. We specialize in fast, high quality work.

25 Years Successful Experience

GULF ENGINEERING CO., INC.
Service Not Promises
1502 INGEBORG ST. HOUSTON, TEXAS
916 S. PETERS STREET NEW ORLEANS, LA.

CONTROL ALGAE AND SLIME
Paddock CHLORINATORS

Operates on high vacuum . . . no moving parts. 8 capacity ranges — 15 lbs. to 2000 lbs. of chlorine per 24 hours. Also ideal for chlorinating drinking water.

Paddock Sales of Texas
Sales Agent for Paddock Engineering Company of Texas
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THE HEART OF ANY PLANT . . .
. . . IS ITS BATTERY OF
HEATERS
FOR EVERY PROCESS THERE IS A
BORN UPFLO HEATER
BORN ENGINEERING CO.
TULSA, OKLAHOMA

manager for the East, Central and Southeast. Formerly district manager at Albany, N. Y., Matlack has been with the company for 18 years.

Devon W. Fryback appointed district manager of the Albany, N. Y., office, succeeding Matlack. With Brown for 21 years, he was formerly industrial manager at Hartford, Conn.

Succeeding Fryback as industrial manager of the Hartford, Conn., district office is D. Lyle Russell, who was transferred from the Boston office.

Herman Hoyler, with Brown for 11 years, named industrial manager of the East Orange, N. J., district office.

R. R. Holmes New Assistant General Manager for Koppers

R. R. Holmes, sales manager of the tar products division of Koppers Company, Inc. since October, 1947, has been appointed assistant general manager of that division.

After attending Emerson Institute, he worked for several years in two banks at Washington, D. C., and for one year at the Mesta Machine Company in Pittsburgh. In November, 1923, he joined Koppers Company in the accounting department. In 1944, after serving as a clerk and a department manager, he was made manager of the Koppers white tar division at Kearny, N. J. He returned to Pittsburgh in October, 1947, to become sales manager of the tar products division.

Howard Millington Appointed Spencer Sales Representative

Spencer Chemical Company has appointed Howard Millington as chemical sales representative in the Chicago, Milwaukee, Minneapolis, St. Paul, Detroit, Cincinnati and Cleveland area. Millington will maintain offices at 208 South LaSalle Street, Chicago, and will represent Spencer on the sale of ammonia, methanol and formaldehyde produced at the Pittsburg, Kan., and Calumet City, Ill., plants of the company.

Millington

Before his recent appointment, he was a member of the market research department of the organization. Previously he was associated with Produc-trol Company and Butler Brothers as management engineer.

Alloy Steel Opens Office

Alloy Steel Products Company, Linden, N. J., has opened a New York sales office with Richard E. Boller, Jr., as district manager. Sales represenatives will be Ralph O. Dale, Henry G. Harley and Elliot A. Baines. The office will serve the metropolitan area including New York state and New England.

Vapor Recovery Moves Office

Vapor Recovery Systems Company, Compton, Calif., has moved its Tulsa branch office to 409 Tuloma Building, Tulsa. W. H. Worsham, sales engineer, will remain in charge of the branch.

A. O. Smith Anniversary

Founded in 1874 as a general machine shop by C. J. Smith and his sons, A. O. Smith Corporation, Milwaukee, Wis., is this year celebrating its 75th anniversary. Herman Welzien, who has served for 58 years with the corporation, is lighting the candles on the birthday cake as J. J. Stamm, veteran treasurer of the company who is in his 51st year of service, looks on.

Raybestos Opens New Office

Raybestos - Manhattan, Inc., Passaic, N. J., has opened a warehouse and office at 314 Occidental Avenue, Seattle, Wash., for the convenience of its customers in the Pacific Northwest. A complete stock of industrial rubber products will be carried. Russell G. Heuman is to head the new office.

STEEL DRUM
RECONDITIONING
MACHINERY
IN WORLDWIDE USE
REDUCES DRUM COST
SEND FOR LITERATURE
L. M. GILBERT CO.
DREXEL BLDG., PHILADELPHIA, PA.

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CHEMICAL ENGINEER

Exceptional opportunity offered engineer with experience in the fundamental design and operation of natural gas processing equipment. Primarily want person with ability and knowledge to direct and supervise engineering program and assist in sales. Letter of application should include photograph, personal data, record of education and experience, references, and expected salary range. Address: Box 121R, c/o Petroleum Refiner, Houston, Texas.

QUALIFIED PUMP ENGINEER

with experience in refinery and chemical type pumps.

Must have thorough knowledge of various types of pumps and their application, packing, seal oil systems, materials of construction, and be able to write specifications, select proper equipment and assist in designing installations. Applicant should have about ten years' experience. Location—New England. Address: Box 131-R, c/o Petroleum Refiner, Houston, Texas.

CHEMICAL MANUFACTURING OR OIL REFINING EXECUTIVE desires change. Extensive experience and accomplishments. Age 48. Bracket $10,000 to $15,000. Address: Box 130-R, c/o Petroleum Refiner, Houston, Texas.

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LIVINGSTON, N. J.

FOR SALE—Three Worthington horizontal duplex hot oil pumps, 23 x 5 x 24, with forged steel liquid ends, rated 750 pounds square inch discharge pressure. Used in refinery operation. Good for irrigation projects, plastic industry, paper plants. Good condition. R. H. Armstrong, Republic Oil Refining Company, Texas City, Texas.

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38,000 Feet New Seamless Pipe

14" O. D.
30' to 40' Lengths
Range 3
.375 WALL: 54.5 lbs. per ft.
Plain Ends
Immediate Delivery

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Derricks, cranes, hoists, rigging specialties; winch trucks, pickups, jeeps; welding machines, acetylene torches; air compressors; pneumatic hammers, chippers and drills; electric saws, drills, drill presses, and grinders; pipe threading machines and tools; wheelbarrows, concrete carts, concrete buckets, vibrators, pumps, rod benders, shears; etc. — for BARE BASIS RENTAL.

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Charges are for rental only, plus our direct costs of handling, shipping, maintenance and reconditioning. Rental by written contract, with minimum rental period, on a monthly basis. Credit references will be needed at the time of inquiry.

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THE LUMMUS COMPANY, 420 Lexington Avenue, New York 17, N. Y.

Telephone: Murray Hill 9-2525 - Ext. 257

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Cut Tower-Cleaning Costs the Easier Oakite Way!

EVER heard this said? "Towers can't be cleaned without disassembling equipment!" That may have been true years ago but not anymore.

Absorber towers (as well as stills, stabilizers and other refinery equipment) are being cleaned in-place every day by the economical Oakite continuous-circulation method. The Oakite way eliminates hand cleaning method. Eliminates costly shutdowns. And it's most economical!

Ask the Oakite Man near you, or write for full, free data on how to step up output through tested Oakite continuous-circulation cleaning. Oakite Products, Inc., 50B Thames Street, New York 6, New York.

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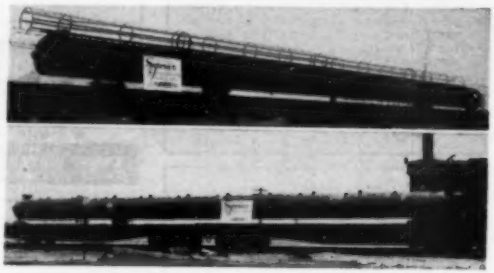
MATERIALS • METHODS • SERVICE

SUPERIOR-BUILT *means superior build!*

It took two cars to deliver each of the fractionating towers in the picture below. Each was 90 feet long with diameters of 48 inches. Each was built to Superior standards and to the specifications of an East Texas refinery. No matter what the job, you are assured the best of workmanship, the finest engineering, the best obtainable materials and the speediest of service . . . Superior-built DOES mean superior build.

For Information or Estimates Call Amarillo 4395



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HEAT EXCHANGERS
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PUMPS

BUILDERS OF OUTSTANDING PUMPS SINCE 1869

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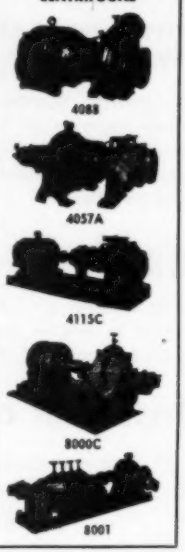
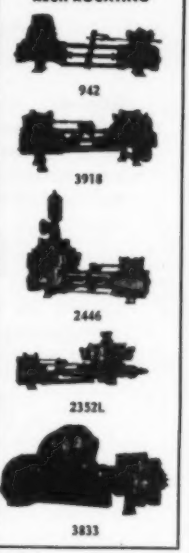


RECIPROCATING



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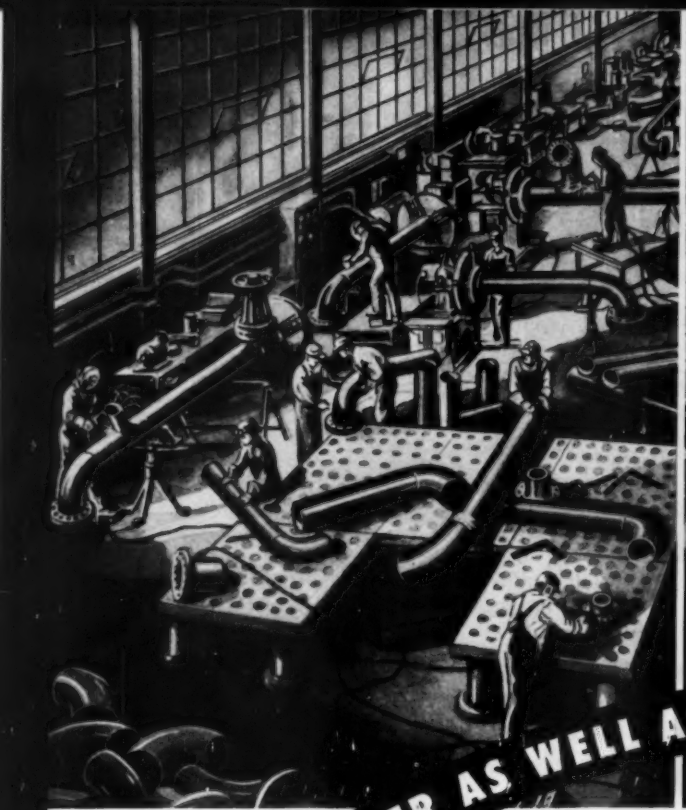
NEW YORK HOUSTON



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HAS THE "Customer's Viewpoint" ON PIPE WELDING FITTINGS

The four Midwest pipe fabricating plants, and the Midwest Contracting Department are among the large users of Midwest Welding Fittings.

Hence, we have the "customer's viewpoint" when it comes to welding fittings. We know from our own experience what characteristics welding fittings must have to simplify piping layout . . . to reduce welding time . . . to improve piping design. The welding fittings manufacturing department always has the benefit of our extensive user experience.

This situation is one important reason for the high quality and exceptional practicality of all Midwest Welding Fittings. Also important are the laboratory control of manufacturing procedures and the program of continuous research in piping and welding problems.

For more information about Midwest Welding Fittings, get in touch with the local distributor or our nearest office.

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WELDING FITTINGS IMPROVE DESIGN AND REDUCE PIPING COSTS

Your Heat Exchanger Dollar $ Goes Further . . .

AT WHITLOCK

WHITLOCK
HEAT TRANSFER
EQUIPMENT

Right

IN EVERY WAY

1. Thermal Design
2. Mechanical Design
3. Material Selection
4. Quality Fabrication
5. COST ECONOMIES

It pays to watch these unseen factors

COST economies at Whitlock are the result of sound engineering, plus constant attention to eliminate waste in design, construction, and operation. To stretch your heat transfer dollar . . . in both first cost and after installation . . . Whitlock units are sized right. Every possible saving is made through the selection of the most satisfactory material.

Through the Whitlock standardization program you gain another outstanding economy. Standardization reduces engineering and manufacturing costs . . . making available a wide range of stock units for many highly specialized services. Whether standard or "special," however, every Whitlock unit is built for top performance and long life. There's lasting economy in this equipment that's "Right in Every Way." Our engineers will gladly make recommendations—let us know your specific requirements.

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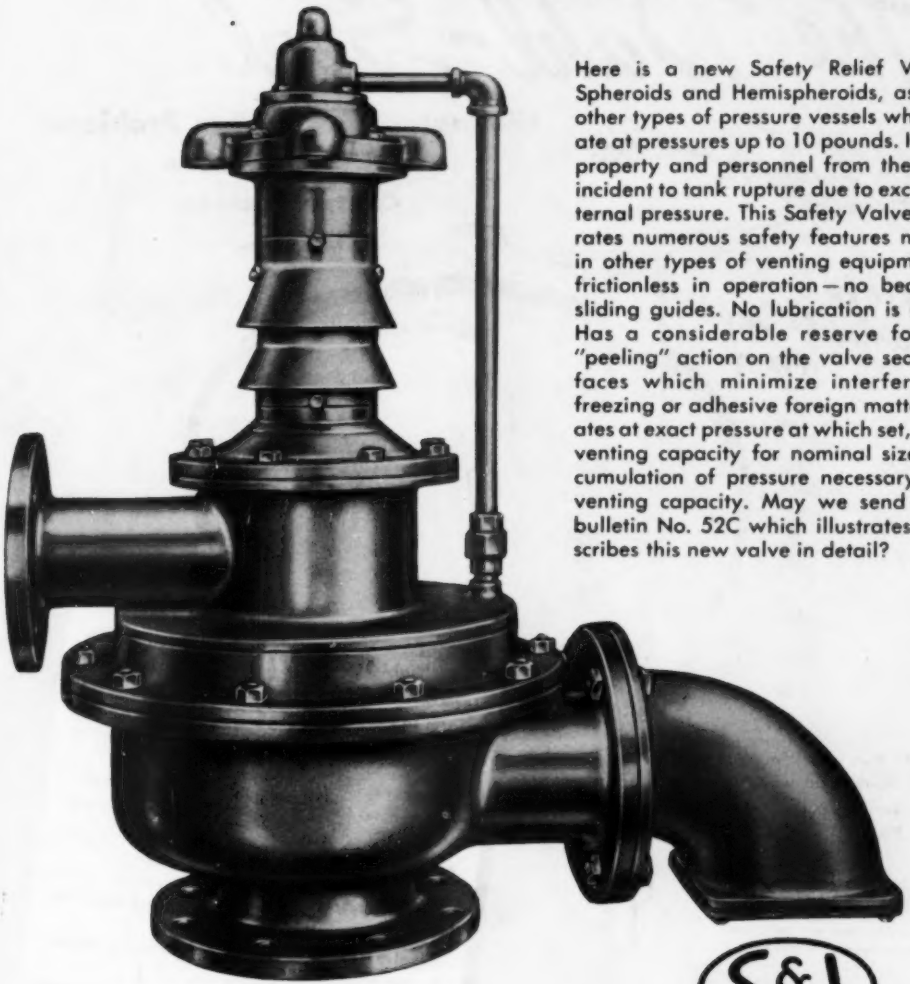
New SAFETY RELIEF VALVE FOR PRESSURE VESSELS



Here is a new Safety Relief Valve for Spheroids and Hemispheroids, as well as other types of pressure vessels which operate at pressures up to 10 pounds. It protects property and personnel from the hazards incident to tank rupture due to excessive internal pressure. This Safety Valve incorporates numerous safety features not found in other types of venting equipment. It is frictionless in operation—no bearings or sliding guides. No lubrication is required. Has a considerable reserve force plus "peeling" action on the valve seating surfaces which minimize interference by freezing or adhesive foreign matter. Operates at exact pressure at which set, has high venting capacity for nominal size, no accumulation of pressure necessary for full venting capacity. May we send you our bulletin No. 52C which illustrates and describes this new valve in detail?

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AUTOMATIC CONTROL EQUIPMENT

ENGINEERED DESIGN BY **HAMMEL-DAHL**

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Eliminates Packing Box Problems on High Pressure Control Valves

ANOTHER Hammel-Dahl FIRST

Hammel-Dahl manufactures High Pressure Control Valves for operating pressures up to 15,000 PSI.

The Valve Illustrated is the Hammel-Dahl 6" Type 7723ST High Pressure Valve with Dahl-Seal. Pressure tested at 22,500 PSI.

The "Dahl-Seal" provides a frictionless, leak-proof Valve stem, regardless of the static pressure in the system.

1. The valve stem can be positioned to an accuracy of 0.001" in high pressure valves at operating pressures up to 15,000 psi.
2. Eliminates conventional packing box leakage.
3. No periodic take-up or adjustment is necessary.
4. Seals by force of system pressure.
5. Negligible stem friction at any pressure
6. Completely resistant to chemical attack.
7. Can be used for any temperature for which the valve is designed.
8. Available for any Hammel-Dahl Valve, including those now in service.

HAMMEL-DAHL COMPANY

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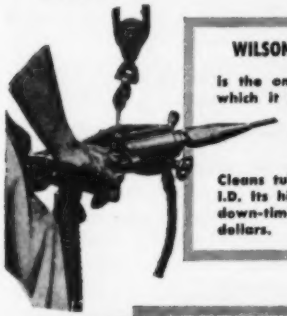
SCALE IS OUT!

WITH THIS TRIPLE-PLAY WILSON COMBINATION

For Cleaning small tubes of heat exchangers, the perfect "inner defense" is this Wilson threesome . . . the Wilson Trigger Power, Pistol Grip and the S Series Air or Steam Driven Cleaners. ● Each of these Wilson Tube Cleaners does a fast, thorough, economical job. Just choose the right one by determining the number and size of tubes to be cleaned.

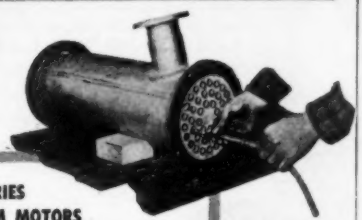


WILSON TRIGGER POWER

is the only tube cleaner with which it is economically practical to remove deposits from plugged tubes without damage to tube walls. Cleans tubes from ⅜" to 1¾" I.D. Its high torque speed cuts down-time, saves production dollars.

WILSON PISTOL GRIP

weighs only three pounds . . . gives the operator one-hand control for cleaning small straight tubes of ¼" to 1" I.D. in sterilizers, hot water heating units, lube oil heaters, oil preheaters, heat exchangers and other small bore tubular apparatus.



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WILSON S SERIES AIR OR STEAM MOTORS

were especially developed for cleaning small straight tubes from ⅝" to 1¾" O.D. These light, powerful air or steam motors may be used with equal ease in horizontal or vertical installations. They require minimum space for operation.

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for additional information on these

WILSON TUBE CLEANERS

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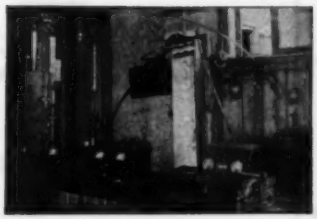
WILSON
TUBE CLEANERS

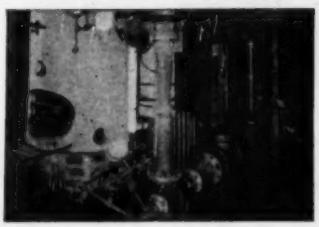
What's *behind* a CROLL-REYNOLDS Evactor?

1

Instruments in the CR laboratory set up for measuring extremely high vacuum.



The production of Evactors is no routine operation at the Croll-Reynolds plant. Although CR engineers have over thirty years of industrial vacuum experience to guide them, the Croll-Reynolds testing and development department is one of the important units of the company. Development work is constantly under way to improve the efficiency of Croll-Reynolds Evactors wherever it is possible. It is this never-ending research and development which give CR Evactors their exceptional efficiency.



2

Special boiler in the CR pilot plant for providing unusual conditions of high pressure steam or superheat (or both) to duplicate the working conditions in customers' plants.

3

A 30-inch CR Booster Evactor on test in a CR shop.

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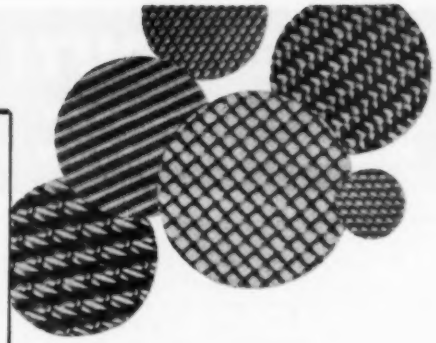
CHILL VACTORS STEAM JET EVACTORS CONDENSING EQUIPMENT

Compare this *Screen* and *Filter Cloth* with any you are now using!



FILTER and screen elements need not be weak spots in your equipment.

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Many equipment manufacturers already have standardized on elements of Monel, Nickel or Inconel. Maybe your manufacturer is one of them. But maybe he isn't. So speak to him. Let him know you want the protection of the "task metals" wherever filters, strainers or screens are used.

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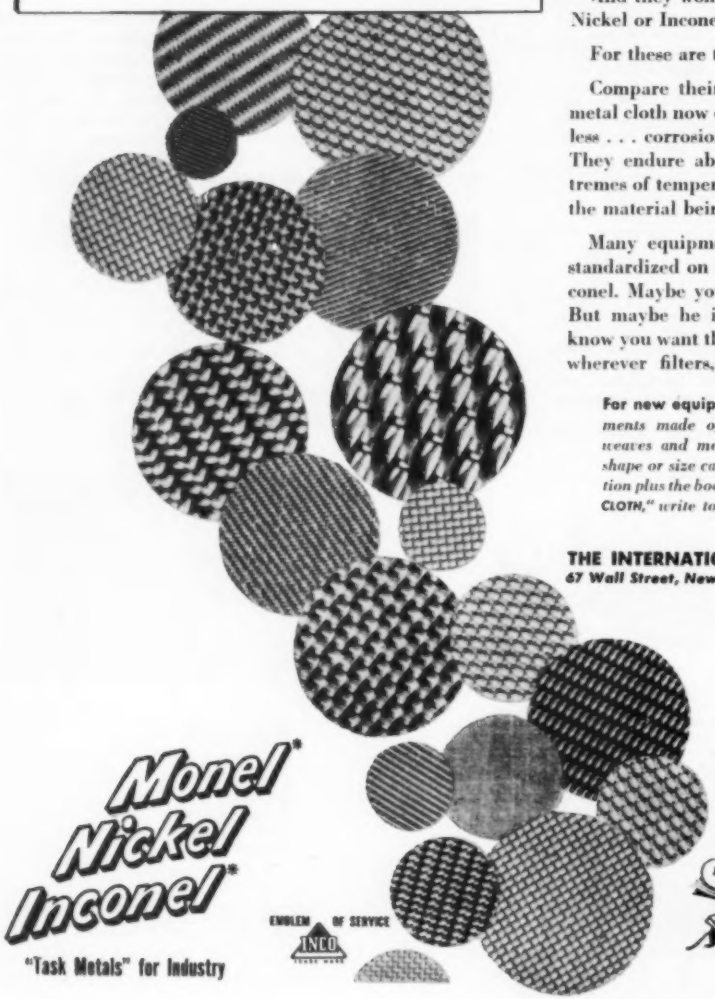

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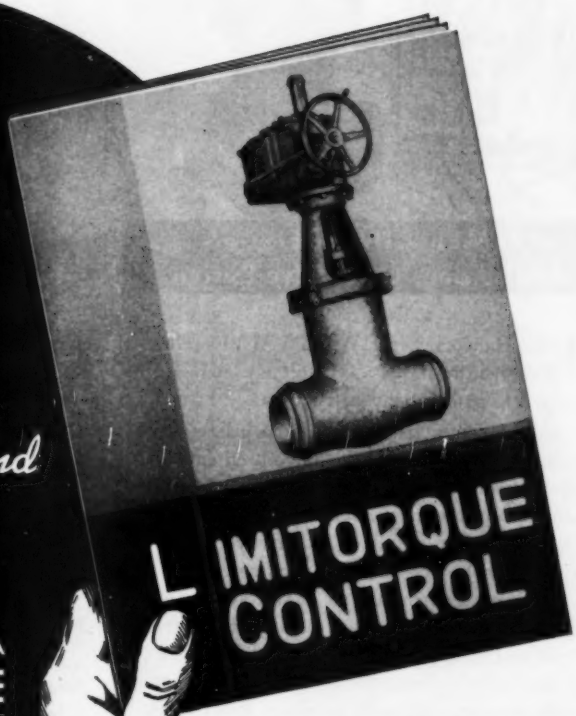

Hundreds upon hundreds of valves on land and sea—for every conceivable use, are being safely, speedily and dependably opened and closed by *LimiTorques* day in and day out.

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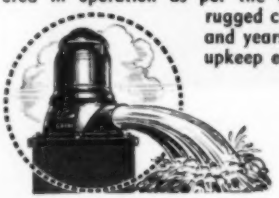

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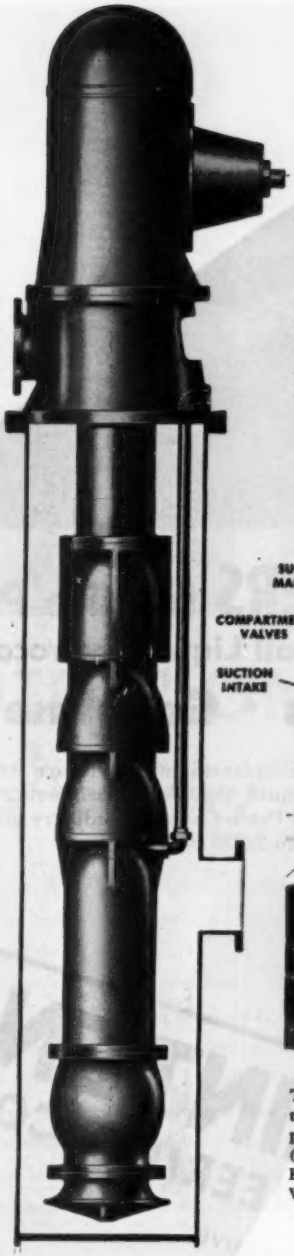
CLOSE STRIPPING

is fast and simple

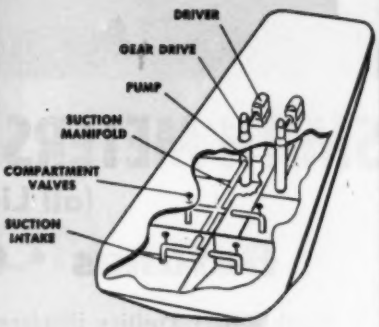
with the new

BJ

STRIPPER PUMP



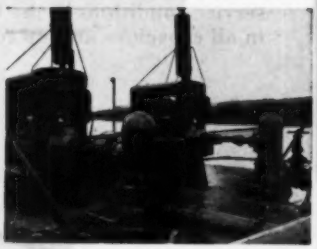
This heavy-duty, compact, vertical multi-stage pump strips barges, tanks, or other vessels more quickly and more thoroughly than any other pump ever used. It has been designed to do a specific job.



The BJ Stripper Pump is of the multi-stage type. A unique and very important feature of the design is a *special priming stage* located at the bottom and connected to the main pumping element by a vapor chamber.

SELF-PRIMING—When the pump starts, liquid from the priming well is forced by the priming stage into the separating chamber to seal the priming stage. When sealed, the priming stage operates as a vacuum pump to *exhaust vapors or air from the suction line,* discharging them through the vent line into the cargo compartment or tank. Thus the common source of difficulty in stripping operations is eliminated.

User reaction to BJ Stripper Pumps already in the field has been enthusiastic. We invite your inquiries.



These two BJ pumps reduce stripping time to 10 hours less than that required previously with other equipment. (Pumps are installed on a Mississippi River gasoline barge, operated by the Wood River Oil & Refining Company.)

TWO STANDARD SIZES AVAILABLE

SIZE	STRIPPING CAPACITY	HEAD
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16"	1150-2700 gpm	TO 500 FEET

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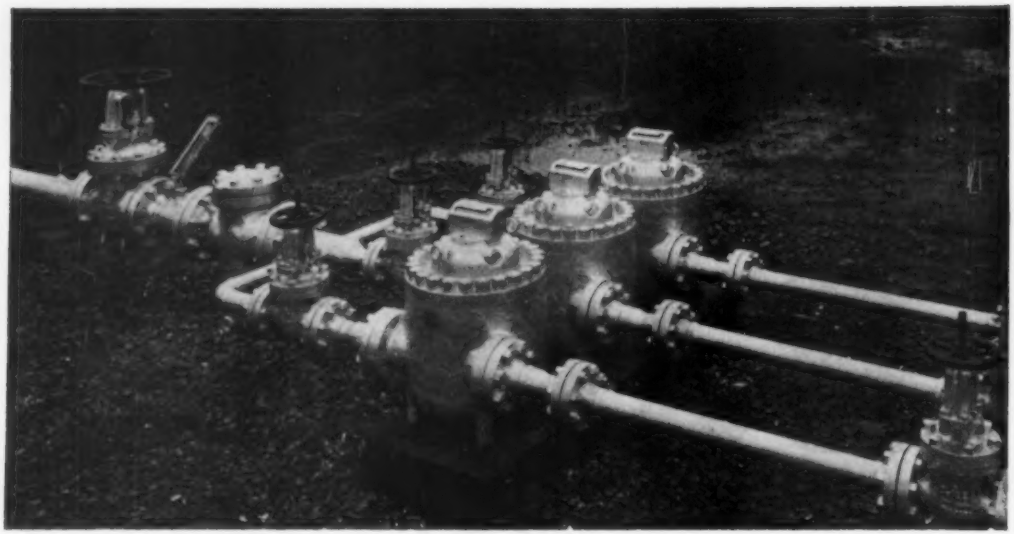

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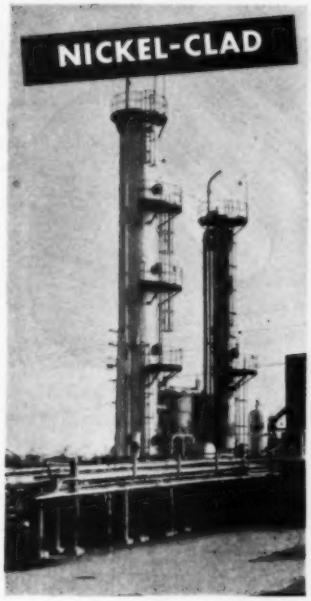

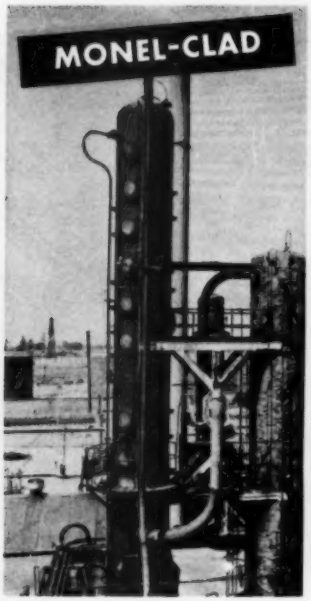

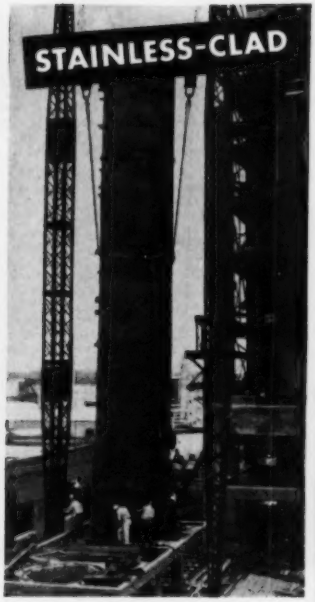

PROTECTION

is built *into* this refinery equipment

Each of these towers is constructed of a Lukens Clad Steel—a corrosion-resistant interior surface of nickel, Monel or stainless steel, according to the corrosive conditions encountered, permanently bonded to ASME steel backing plate. Thus, long equipment life and product protection are combined with high strength at the lower cost of *clad* steels.

Where equipment is subjected to one type of attack at one point and other corrosive conditions at another, different types of clad steels are employed in those sections. For example, Lukens Monel-Clad and Stainless-Clad Steels frequently team up in fractionating towers to defeat corrosive attack.

Lukens makes Nickel-Clad, Stainless-Clad, Inconel-Clad and Monel-Clad Steels in plate to over 3 inches thick or to as wide as 178 inches. Bulletin 461 shows applications in the Petroleum Industry. For a copy, write Lukens Steel Company, 404 Lukens Building, Coatesville, Pennsylvania.

CLAD METAL STEEL

LUKENS

Nickel-Clad Stainless-Clad
Inconel-Clad Monel-Clad
STEELS

Two 16mm Kodachrome motion pictures—"The Manufacture of Lukens Clad Steels" (silent) and "Solving Corrosion Problems" (with sound)—will be loaned to you. Write for booking date.

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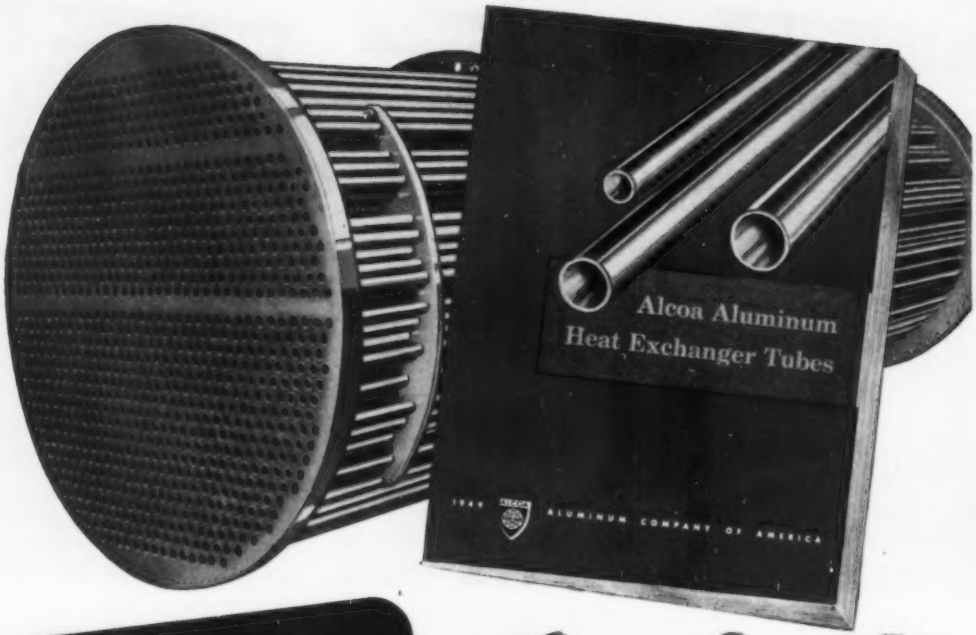
• • SPEED SCRAP TO THE MILLS TO MAKE MORE STEEL • •



Booklet tells you why Aluminum Tubes stand up better against H_2S and products of sour crude

On your heat exchangers handling products of sour crude, H_2S, CO_2, or ammonia, you'll get two to 10 times the life from Alcoa Aluminum Heat Exchanger Tubes. Aluminum has high resistance to corrosive attack by these products, as well as by steam and most cooling waters.

Alcoa Aluminum Tubes are made in all standard diameters and wall thicknesses, in bare tubing for almost all refinery products and many cooling waters, in *Alclad* Tubing to stand up against highly corrosive fresh and salt waters.

Tube sheets of Alcoa Aluminum are recommended to give maximum life with Alcoa Aluminum Tubes. You can use standard fabricating methods and tools, and usual good roll-in procedures.

Get the facts on Alcoa Aluminum Heat Exchanger Tubes. Install a trial bundle on your next retubing job.

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ALCOA ®

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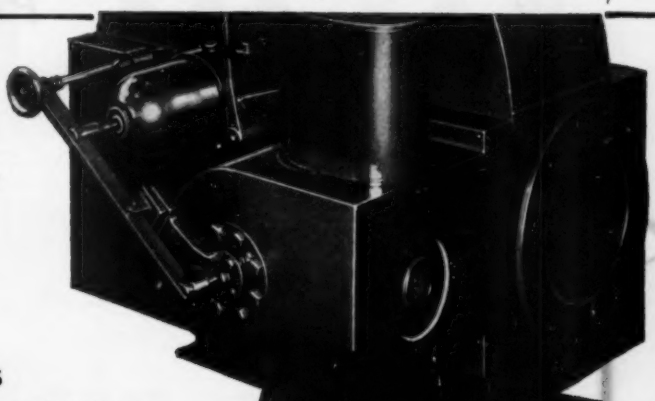

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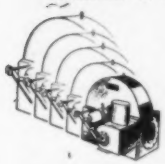
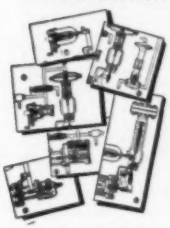


5 frame sizes

covering horsepower range from 1 to 2000. Exhaust pressures to 250 psig. Speed range from 800 to 6000 rpm. All with permissible inlet pressure of 600 psig, and inlet temperature of 750 F. For low pressure, construction is of cast iron. For high pressures and temperatures, cast steel is used.



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In addition to the standard independent emergency governor, any of these six governors is available: (1) Constant speed mechanical shaft . . . (2) Variable speed orifice type . . . (3) Variable speed orifice type with remote control . . . (4) Constant-speed oil relay type . . . (5) Variable-speed oil relay type (6) Built-in constant or differential pressure pump type.

With this wide choice of governors, you can get constant speed, normal regulation, close regulation or any combination of these.

Other available modifications

Two hand valves for part load economy . . . Speed changer, hand-operated, or motor- and hand-operated, adjusted to within plus or minus 10 per cent. . . . High exhaust pressure trip, or remote control electrical trip, actuating emergency trip valve . . . Throttling type emergency trip valve for hand throttling . . . Gland seal piping for condensing operation . . . Gland sealing for gas operation.

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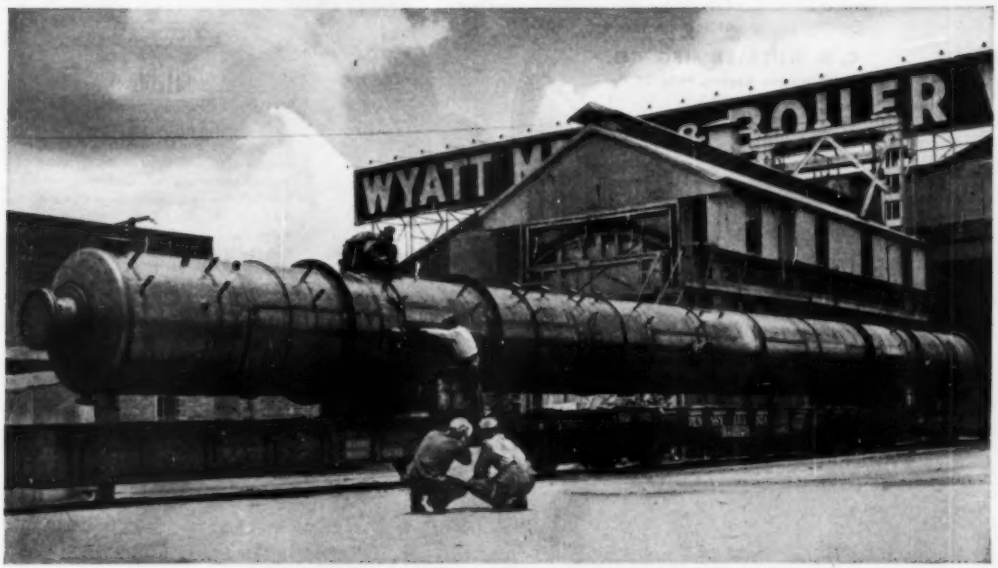
For STRENGTH in FRACTIONATING COLUMNS

HERCULOY



Fractionating column, 108' 6" high, 78" I. D., fabricated out of Revere's Herculoy by the Wyatt Metal & Boiler Works, Houston, Texas.

FRACTIONATING columns need strength, because of their height, and also because they often must resist considerable pressure. They also must be immune to attack by the fluids and vapors involved in the fractionating process.

Such specifications of the chemical industry spell Herculoy. This copper alloy is Revere's silicon bronze, a remarkable metal with the corrosion resistance of copper, and the strength of mild steel. Herculoy Alloy No. 420, for example, has a tensile strength of 94,000 psi, for sheet in hard temper, and 60,000 psi, soft. It can be readily welded by any of the commercial methods.

The illustration shows a giant column made of Herculoy by the Wyatt Metal & Boiler Works, Houston, Texas. Fabrication: welding by Heli-arc method, using Herculoy 420 welding rod. The column stands 108' 6" high, and the inside diameter is 78".

It is a pleasure to report that more and more Herculoy is being used by fabricators for the refining and chemical industries, not only for fractionating columns, but also for tanks, pressure vessels, and other applications in which strength and corrosion resistance are vital. The Revere Technical Advisory Service will gladly collaborate with you on Herculoy, which is made by Revere not only in sheet, strip and plate, but also in rod, wire, tube and forgings.

REVERE

COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

230 Park Avenue, New York 17, New York

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Mills: Baltimore, Md.; Chicago, Ill.; Detroit, Mich.; New Bedford, Mass.; Rome, N. Y.— Sales Offices in Principal Cities, Distributors Everywhere.

Pioneering Large Plastic Fans for Water Cooling Towers

Another C. H. Wheeler FIRST! Plastic fan blades for the "biggest" cooling towers. The same type plastic fans available for years for smaller C. H. Wheeler cooling towers now can be supplied for large sizes. Scores of users have experienced their superior resistance to corrosion, moisture, and abrasion. Names of installations will be sent on request. . . . What's more, these plastic fans are tested, approved and carry the "Certified Rating" of PFMA (see right). Fan blades have adjustable pitch and a 20-to-1 safety factor at the welded steel hub. Cooling tower catalog on request.

C. H. WHEELER MFG. CO.
1818 Sedgley Avenue, Phila. 32, Pa.
REPRESENTATIVES IN MOST PRINCIPAL CITIES

Plastic Fan Blades Used for Years in Small and Medium Size C. H. Wheeler Water Cooling Towers

now

C. H. Wheeler Introduces Plastic Fan Blades for Large Towers

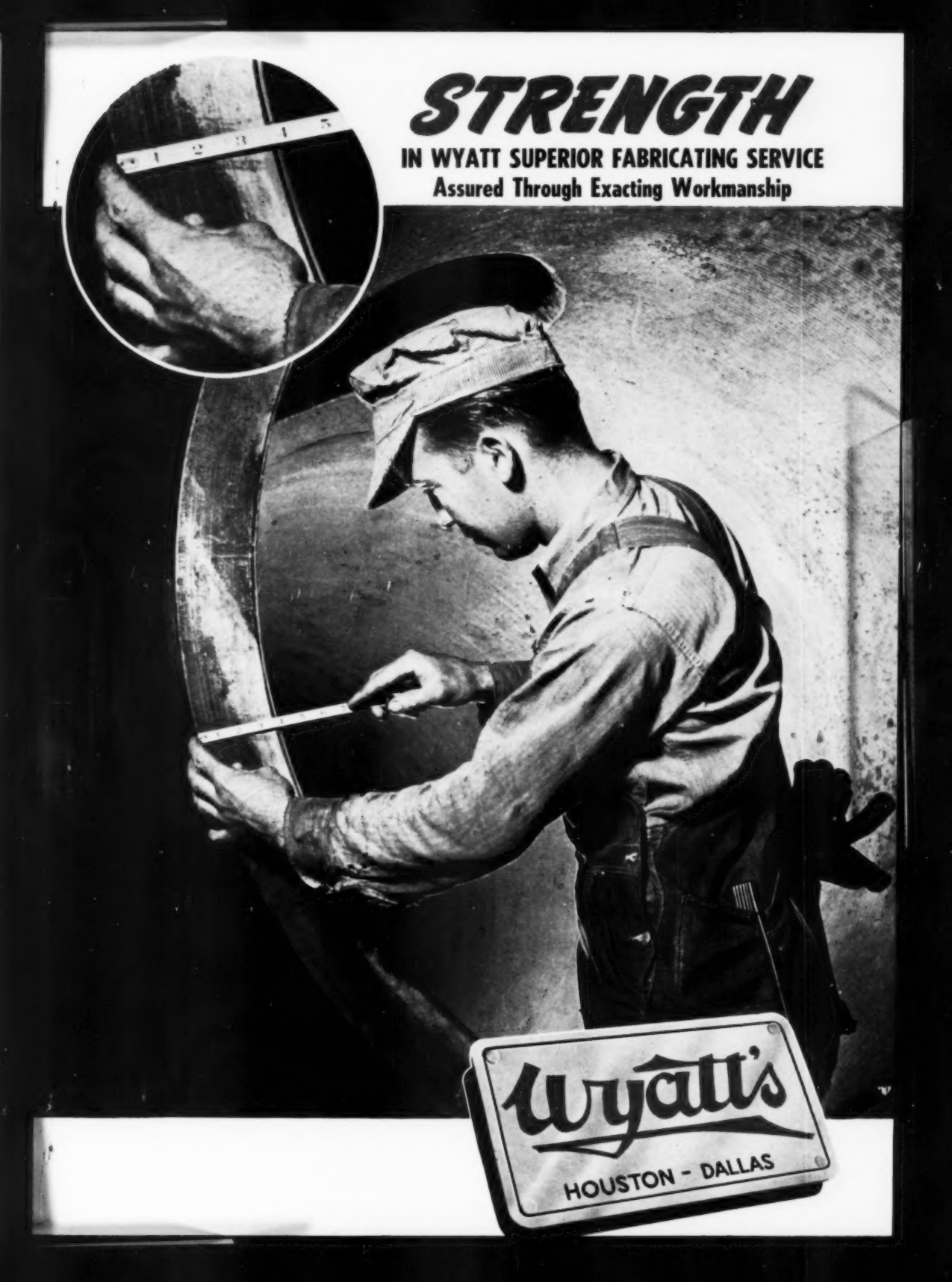
Certified Ratings

PFMA

The Propeller Fan Manufacturers Association was organized early in 1939, and all members are known by the Certified Rating Insignia shown above. All fans manufactured by members are tested for air delivered in accordance with the Standard Test Code for Centrifugal and Axial fans which was adopted jointly by the National Association of Fan Manufacturers and the American Society of Mechanical Engineers, and in 1939 by PFMA.

C.H. Wheeler OF PHILADELPHIA

STEAM CONDENSERS • WATER COOLING TOWERS
EJECTORS • STEAM JET VACUUM REFRIGERATION


STRENGTH
IN WYATT SUPERIOR FABRICATING SERVICE
Assured Through Exacting Workmanship
Wyatt's
HOUSTON - DALLAS

McDONALD

Swing Joints

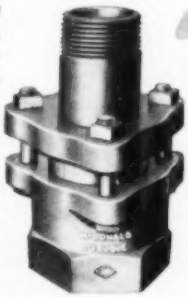


Plate 889—McDonald Standard Swing Joint (Straight). Iron body, bolted iron gland, bronze ferrule. Available in 1¼", 1½", 2", 2½", 3", and 4" sizes.

Plate 814—McDonald Standard Swing Joint (Double). ¾", 1", 1¼", 1½", 2", 2½", 3", 4", 6", 8", 10"

Recognized Throughout The World as TOPS in Design, Workmanship, Performance

Ever since we originated the Swing Joint years ago, we have concentrated on the objective of perfect performance . . . You'll find evidence of that policy in the many engineering advances that McDonald Swing Joints embody, in their precision manufacture, in their amazing ability to deliver years of trouble-free service, and in their worldwide reputation as the finest products of their kind. To look for the McDonald mark is such a sure and simple way to get more for your money.

A. Y. McDONALD MFG. CO.

"The Home of the Swing Joint"

DUBUQUE, IOWA

There's a McDonald Branch or Distributor Near You

Plate 984 — McDonald Master Swing Joint (Double). Highest development of Swing Joint design. Grease-gun lubrication—all-brass construction — unbelievable ease of operation. 1½", 2", 2½", 3"

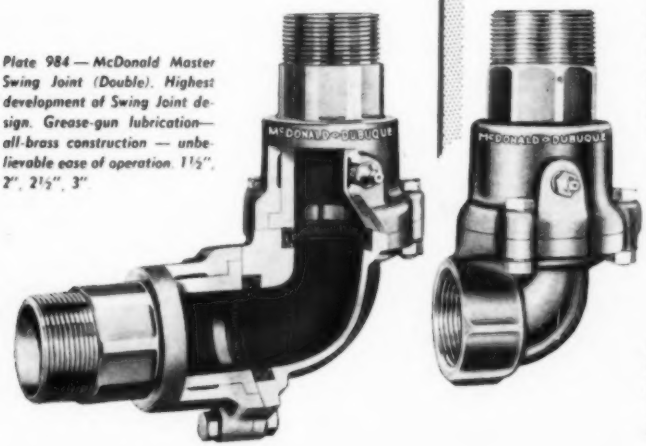


Plate 983—McDonald Master Swing Joint (Single). A single ring is used for packing—replaceable, if required, in jiffy-quick time. 1½", 2", 2½", 3"

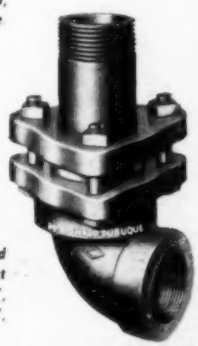


Plate 813—McDonald Standard Swing Joint (Single). ¾", 1", 1¼", 1½", 2", 2½", 3", 4", 6", 8", 10"